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Man's Hand Against the Sky

The Problems of PUBLIC ENTERPRISE

By WALTER RAUTENSTRAUCH[1]

What we are really striving for is to find a way to get rid of the combative and competitive method and get down to a sensible basis of living. We are seeking to establish a balanced flow of production, distribution, and consumption in the nature of public enterprise, and rid ourselves of the disturbances, dissatisfactions, and wastes of private enterprise. To accomplish this objective we need to develop a balanced and integrated system of procedure, in which all functions are operated on a controlled basis.

Our studies indicate that the remedy for our present conditions does not lie in the direction of hoping for many new industrial developments. New industries are of course to be encouraged, but the problem still remains of devising a method by which these, along with those already established, may be incorporated in the social system under a balanced quantitative control of production, distribution, and consumption.

IT MUST be apparent to any observer of social phenomena that we are passing through a period of changing concepts with respect to industrial enterprise. We are gradually emerging from the era of private enterprise and entering upon one of public enterprise. This is not the result of any political movement, nor does it arise from the promulgation of any social doctrine. It is happening through the simple process of social change. We have changed our methods of converting natural resources into commodities and services, and by this change have altered the relative claims of labor and capital to share in the goods produced.

We have built up an aggregate of specialized functions in the business process, and have operated them as independent units without regard to their interdependent relationships. We have built large industrial establishments, factories, railways, mines, structures, on a competitive basis and with public funds.

Banking institutions, both public and private, have grown up as institutions competitive among themselves, and their operations have not been related in any rational way to the economic and social forces upon which their own life and growth depend. Our currency and credit-capital systems bear no rational relation to goods and services.

Every functional division of the social mechanism seems to have been developed as though it could operate in relation to other functional divisions by occasional manual adjustments. We are experiencing the breakdown of this method of operation. We are learning that an aggregate of operations is not an orderly system.

THE FACTS INVOLVED

Now the simple facts of the matter are these: (1) We find ourselves living together on a continental area from which we must derive our ood, clothing, and shelter, and the resources available to this end are not unlimited. (2) We have proceeded to make use of these resources as though they were unlimited and inexhaustible. (3) We have created a very complicated aggregate of practices concerned with the ownership and release of the natural resources, their conversion into commodities and services, and methods by which they are made available for human consumption and use, which do not work in balanced harmony. In fact the whole mass of activities concerned with the problem of living is so mixed that no one seems to be able to state the why and how of it all. (4) We each desire to live like human beings and enjoy life for the few years we are here, and develop our higher natures. But we are under such pressure of strife to provide ourselves and our dependents with the materials essential to existence and comfort that we have accepted a pattern of life against which our inner nature rebels. (5) Accordingly what we are really striving for is to find a way to get rid of the combative and competitive method and get down to a sensible basis of living. (6) We are seeking a way to establish a balanced flow of production, distribution, and consumption in the nature of public enterprise, and rid ourselves of the disturbances, dissatisfactions, and wastes of private enterprise. (7) To accomplish this objective we need to develop a balanced and integrated system of procedure, in which all functions are operated on a controlled basis (not in a legal sense, however) so that living will have some sense.

The usual replies to statements of the foregoing character are that it is against human nature to live that way, that man is a combative animal, that we have always lived on a competitive basis and therefore will continue to do so, that man is by nature deceptive and selfish and will not work on a cooperative basis, etc., etc.

Now, while we cannot overlook whatever validity

[1] Professor of Industrial Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

From an address before the Metropolitan Section of the A.S.M.E., New York, January 16, 1933.

in experience there may be to support these assertions, the fact must nevertheless be recognized that the pressure of new circumstances may compel a new orientation. Because we have muddled through previous depressions, can we also muddle through this one, and then wait for the next and muddle through again? Or are we going to really face our problem as men, determine the facts with which we are dealing, and endeavor to build up some sane and sensible method of living?

One of the difficulties encountered in every discussion of the problem is that we must use words and expressions which have such a variety of meanings. Even now many persons believe that when the expression "public enterprise" is used we mean public ownership, and that as public ownership means socialism, this is just another way of recommending socialism. "Public enterprise" is used in the sense of fact, and in no other way.

THE PROBLEM VIEWED AS AN ENGINEERING ONE

Let us see if we cannot discuss this matter as an engineering problem of design. After that the engineering of public consent (practical politics) may be considered by others more familiar with such matters. Let us see if there is any parallel in experience between the problem of design in the growth of a group organism (society), the biological organism, and the technological process. The biologist tells us that those forms of life which have survived have had the capacity of adaptation to environmental change. "Environment" is used in the sense of life-sustaining resources, and "adaptation" refers to the possibility of the organism's drawing upon and converting the available resources to the maintenance of its life-sustaining processes.

The unicellular plants such as the yeasts survive and grow in the medium of the simple proteins of the amino groups because their life-sustaining mechanisms draw upon such energy resources only. More complex biological organisms are adaptable to a large range of life-sustaining resources, and in consequence are capable of survival under greater variations of environmental change. The most complex of all biological entities—man—has evidenced the greatest capacity of all organisms for environmental adaptation to life-sustaining resources. But it is important to note that each successive stage of biological evolution from the cell to man was attended by and made possible because of increasingly complex, highly integrated, and self-adjusting control devices as evidenced by the nervous system, the endocrine glands, and other functional elements of adaptation to environmental impact.

The history of the development of technological processes indicates that the same kind of evolutionary growth has attended the creation and functioning of its ever increasing complex forms. The simple hand tools under the control of human intelligence have become the complex automatic machine because the functional operation of the tools has been integrated with the control devices of the machine.

The modern power station does not exist because of the turbine, the boiler, the feedwater heater, the pumps, and its many other highly functionalized units alone. The possibility of these large energy-conversion systems resides in the integrating control devices with which they are articulated and by means of which there exists the most complete adaptation of their functional operation to the impact of load demand, that is, to environmental change. The same conditions have been manifest in the growth of the modern factory from the simple machine shop.

BIOLOGICAL ANALOGIES

Do the same laws which condition the existence and growth of complex biological organisms and intricate technological processes also operate in the development and growth of increasingly higher forms of group organisms? Are the several stages of social evolution dependent on an attendant development of integrating forces which are self-regulatory and balancing? Can we develop into higher and more complex forms of organized society without the existence and use of integrating and regulatory equipments which adapt society to its ever changing life-sustaining resources and processes?

Since modern society is a group organism composed of the biological entity man, functioning in an industrial system of technological processes, it would seem that its existence and development are dependent upon the same conditioning factors that determine the life processes of its elements. Higher forms of modern society are possible only in conjunction with higher forms of integrating and self-balancing equipments.

In the long series of biological evolutions from remote and distant ages to modern times, from the ameba to man, we note three basic elements of the life process: the invariant factor of dependence on the energy of the earth's resources, the variant factor of energy-conversion processes, and the variant factor of new functional forms; the constant physical needs and their common source of nourishment, the expanding types of integrated energy-assimulating processes embodied in increasingly complex mechanisms, and the birth of the reason and the emotions and all that complexity of functional form commonly termed the spiritual nature of the biological organism called man. And we also note that in the long series of evolutionary transformations culminating in man, not only are new forms of processing and integration acquired, but old forms of operation and control are discarded. The higher functions are possible only as the higher forms of control are incorporated in the process.

If then there be any correlation or parallel between the growth of biological organisms, the growth of technological processes, and the development of higher forms of the social order, may we not anticipate the need of more highly integrated and self-balancing social controls which will permit the realization of man's urge to express himself in terms of spiritual meanings and growth as well as to supply his physical and biological

needs while functioning as a unit in the group organism. The disturbances of the social order arise from the desire of man to live, and to live more abundantly, and because of the frustration of this desire by the failure of our devices of social control to function properly, that is, their failure to integrate and balance the physical and spiritual needs of man and the technological processes by means of which he now lives with the energy-deriving or life-sustaining resources of his environment. The integration, coordination, and purposeful control of the biological organism, of the technological processes and production systems, and of the group organism (the social order) are fundamentally the problem of organization. And in the same manner that the forms of biological organization of past times have disappeared because they could not be adapted to a changed environment, so also the crude forms of social organization and control must give place to a finer type of coordinated and integrated social mechanism, one better adapted to functioning in the higher-energy civilization that has come upon us during the past 100 years.

The social mechanism presents the same problem to the technologist and engineer that is found in the biological organism and the technological process, and he can see no possibility of a stabilized and advancing social order if the control devices of the systems of regulation, including our economic system and business operations, which are employed are not scientifically designed. The breakdown of any system is evidence of the inadequacy of its design. We have developed a very highly complicated social mechanism, one in which more delicate adjustments are called for and for which more scientifically designed control equipments are demanded. The whole basis of control of the business machine as one element of our social process, should be examined with respect to the adequacy of design of its equipment.

THE PROBLEM OF ORGANIZATION

An analysis of the fundamentals of an organized procedure relating to any group activity, whether it be a church, a school, a manufacturing company, a municipal administration, a state or national government, or any other form of cooperative enterprise, indicates that its success is determined by the excellence of its four major functional divisions, which are:

1. The *purpose* or objective of the enterprise
2. The *program* by which it proceeds to accomplish its purpose
3. The *personnel* upon whom it depends for the performance of the specific duties and functions of the program
4. The *property* or life-sustaining resources available to it for its sustenance and growth.

The progress of civilization on any continental area will be determined by the extent to which these four cardinal equipments of organized procedure are correctly established, integrated, and functioned in the operation of the social mechanism.

The *objective purpose* of the enterprise should integrate and express the highest good for the greatest number of the group. A high purpose is necessary to the creation of an emotional response to the cause. It releases the creative faculties and strengthens the cooperative bonds of action. It acts as a catalyzing agency to integrate the group and build a higher order of cooperation adaptable and adjustable to an increasingly complex environment. One element of purpose in our industrial society should be that man is not to be geared to the machine, but rather that the machine is to be geared to a social program. As the purpose of the group declines in social values, disintegrating influences immediately appear, and the cooperative bond is weakened.

The *program* by which the group proceeds must be possible of accomplishment, and therefore must be founded upon an intimate knowledge of all the characteristics of the equipments it uses to carry out the program. In modern industrial society such equipments are (1) the natural physical resources, (2) the technological and other processes for the conversion of such resources into use forms and services, (3) and the control devices incorporated in our economic and commercial practices. We must be concerned with discovering the magnitudes and characteristics of the energy resources upon which the maintenance and growth of our civilization are founded, evaluating the energy-conversion processes of the modern social order as the basis for establishing a possible program of social growth. We must be concerned with studying the systems of integration and control of our economic and commercial practices to discover what, if any, scientific adequacy may reside in their design.

The *personnel* of the group determines whether or not the purpose is to be high and the program is rational, and it is through the competence of the personnel that a program may be executed. In a highly integrated society or group, not only does the competence of the personnel determine success, but there must also be a high sense of trusteeship. In other words, the personnel must be competent and have character. Any moral breakdown in personnel is destructive to organized groups, since it inhibits the creative and life-sustaining processes. Accordingly, we find the institutions of the home, the church, and the school have a great responsibility in developing that type of personnel which can function in our society. Our educational processes must interpret the experiences of life and give them meaning, for the greater the stock of meanings, the more complete will be the adaptation to changing environment. The specialized and confining experiences of those who function in high places and the resulting narrow range of meanings to life processes together form one of the great factors that retard our advancing civilization.

The *property* values or material resources by which the organized group is sustained are important and essential to its life, but are not the life itself. Therefore the order of importance of these elements of organization

is, we believe, as given above. The high purpose of the enterprise must be uppermost, and property values must be subordinated to that purpose. We may look upon this arrangement as a pyramid, the apex of which is purpose and the base of which is property. If the pyramid is inverted and purpose made the base with property values uppermost in the public consciousness, we are inclined to believe that the situation will be unstable and will not endure.

At the same time, whatever may be embodied in the *purpose* or objective of society with respect to a standard of material well-being must not fail to include consideration of the fact that the *property* or energy available is limited.

IDEALISM MUST BE COMBINED WITH COMMON SENSE

Idealism must be combined with common sense if an organized procedure to deal with a changed environment and the present facts of living is to be evolved. It has been suggested that the era of private enterprise is passing into one of public enterprise. Accordingly all industrial enterprises and the operation of other functional divisions of the social mechanism must be regarded from the standpoint of the public welfare, and therefore must be integrated and balanced in their operations in accordance with public necessity and convenience.

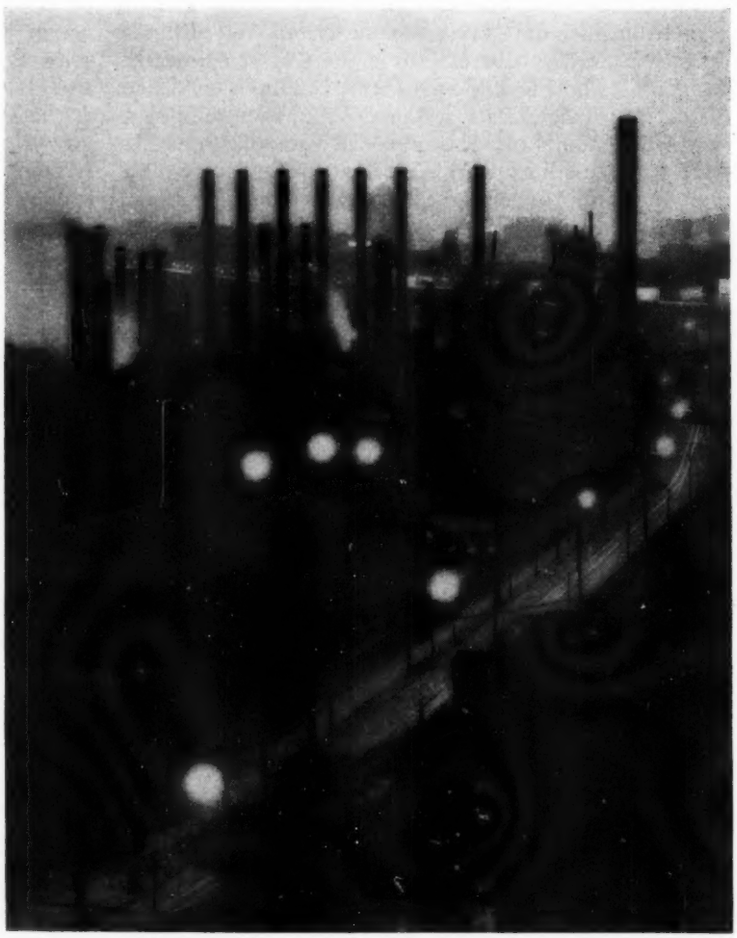
The success of each function of the process of living—production, distribution, and consumption—is dependent on the state of the public welfare, and in turn determines the state of individual well-being.

The whole machinery of living is now too complicated to permit of a balanced flow of goods conjointly with the practices of so-called rugged individualism.

Procedures wholly different from those obtaining in our present commercial and financial practices are indicated if we are to enjoy a sustained condition of economic well-being. It seems hardly necessary to recall the principal factors in our present dilemma—the mounting tide of debt coincident with declining incomes to meet the debt; the great quantities of material; the willing and able workers who are hungry and in need; the idle factories, idle because they cannot be operated at a profit; goods created for profit and not for social need—as evidence of the fact that we are operating by the process of class struggle. Now since this process has been demonstrated to be unsatisfactory to all classes, why not eliminate it and substitute therefor a plan of cooperative reconstruction based on a knowledge of the facts conditioning our economic well-being? Let us embark in the enterprise of building a strong and enduring national life.

The Department of Industrial Engineering of Columbia University has embarked on such an enterprise and hopes to suggest a design of society in which class struggle is impossible, and to discover those principles upon which public enterprise may be founded. We are endeavoring to find the extent of our resources; the characteristics of the processes by which we convert these resources to our uses and the limits under which they may be operated; and the essential functions which need to be performed in the whole process and how they are to be performed in harmonious cooperation for the greatest good for the greatest number.

Our studies indicate that the remedy for our present conditions does not lie in the direction of hoping for new industrial developments in the field of electronic air conditioning and other industrial expansions. Statements of such hope only serve to divert attention from the real problems and raise false hopes by wishful thinking. New industries are of course to be encouraged, but the problem still remains of devising a method by which these, along with those already established, may be incorporated in the social system under a balanced quantitative control of production, distribution, and consumption.



FREIGHT CARS

Effect of Transportation Requirements on Their Evolution

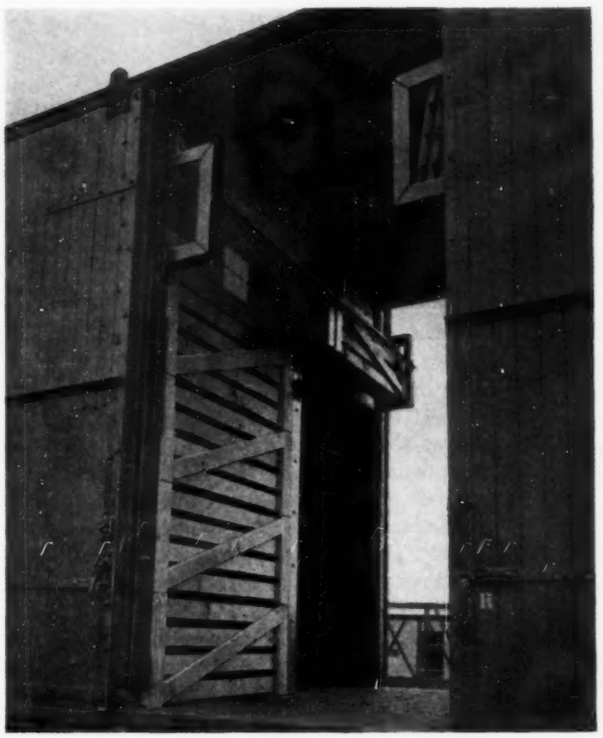
By C. B. PECK[1]

THE type of equipment and the methods of operating American railroads have been determined by the predominance of the raw materials of industry and construction, such as coal, ore, sand and gravel, and the industrial products which have entered in vast quantities into the upbuilding of our capital structure. In 1929, coal, iron ore, sand and gravel, products of the iron and steel industry, cement, brick and artificial stone, and lumber accounted for over 57 per cent of the tonnage of all carload commodities, required 42 per cent of the carloadings, and furnished nearly 40 per cent of the revenue received from freight shipped in carload lots. Coal alone accounted for 34 per cent of the tonnage, 23 per cent of the car loadings, and 22 per cent of the revenue. More than one-third of all freight cars in the United States are of the open-top type.

The products of agriculture, animals, and animal products supplied 11 per cent of the tonnage, 18 per cent of the demand for cars, and 21 per cent of the revenue—less than the revenue received from coal alone. Grain alone accounts for more than one-third of the tonnage, slightly less than one-fifth of the car demand, and more than one-fifth of the revenue.

The cheap handling of bulk commodities has been the dominating factor influencing the evolution of both open-top and box cars and of operating practices, and these cars have grown steadily in capacity. In 1920 the average capacity of the box cars in service on the class I railroads was 37.3 tons. In 1930 it was 41.5 tons. In 1920 the average capacity of open-top cars was 49.4 tons. This had increased to 53.9 tons in 1930. There are three reasons for this increase: First, the cost of switching movements in yards and at terminals is a function of the number of car units handled; second, the ratio of the net to the gross load of a fully loaded car is usually higher in the large-capacity car, and, third, the train resistance in pounds per ton decreases materially as the gross weight per car increases.

But the evolution of our railways into mass-transportation machines with heavy train loads and large rolling-stock units has been accompanied by a gradual increase in the violence of shocks to which the equipment and its lading are regularly subjected in every-day service, both on the road and in yards. The improvements in the stiffness and strength of underframes which have been brought into effect through the agency of the Mechanical Division of the American Railway Association have provided the necessary strength to protect the equipment itself against undue damage from these severe service shocks. Stiff steel ends have provided much-needed protection against the destructive damage to box cars caused by shifting of lading.



FOUR-COMPARTMENT BOX CAR, C. & N.W. RY.

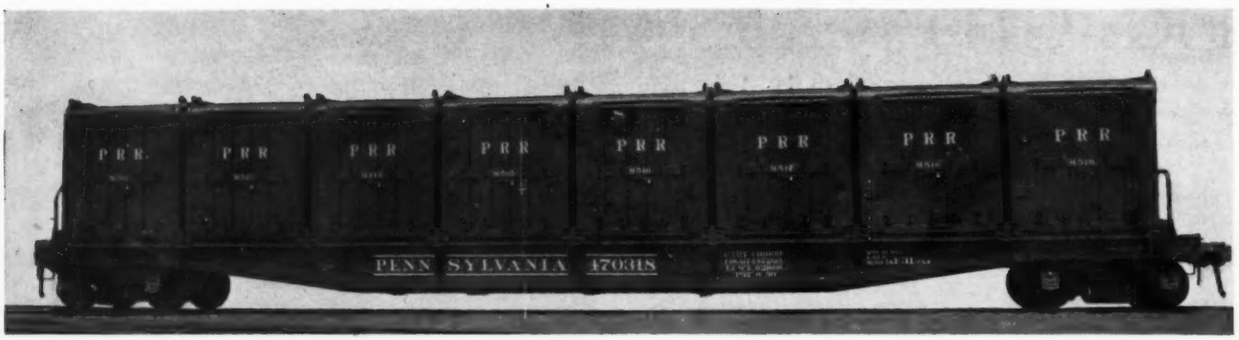
Unfortunately, the development of collision-proof rolling stock does not protect the lading from the effects of violent shocks. Hence most merchandise, either in carload or l.c.l. lots, must be provided with packing or crating which will protect each piece against the destructive effects of the inertia of the entire mass of the large loads which these cars are capable of holding.

BOX CARS

The box car was established in its present essential form long before mechanical labor-saving methods of handling materials were ever thought of and before the operations involved in bringing freight to and removing it from the railway right of way were considered as economic factors of transportation. It is the most universally used container of freight in railway service. In its most general form it is designed to handle grain up to the full axle-load capacity. It serves as a container for a large number of agricultural and industrial products in carload lots, and until the advent of the demountable

[1] Managing Editor of *Railway Mechanical Engineer*, Mechanical Department Editor of *Railway Age*, New York, N. Y. Assoc-Mem. A.S.M.E.

Contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., December 5 to 9, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Slightly abridged.



THE EIGHT CONTAINERS ON THIS CAR ARE LOADED AND UNLOADED BY CRANE

container it was the universal container for the movement of commodities in l.c.l. lots.

But a small part of the car capacity can usually be used for l.c.l. shipments between common loading and destination points. To keep down excessive car mileage, transfer platforms are located at strategic points, through which cars from a given territory must pass to be unloaded, their contents reclassified and reloaded for destination territories, in which, in some cases, the operation may be repeated before delivery is made to destination freight houses. Testimony of three railroads in the container-service hearings before the Interstate Commerce Commission in 1930 gave platform costs for handling shipments of l.c.l. freight of 7.8 cents and 11.55 cents per 100 lb, with clerical costs of 7.8 cents to 12.6 cents per 100 lb, and combined platform and clerical costs from 15.6 cents to 24.15 cents per 100 lb.

Why is a single type of car, the size and capacity of which are fixed by the requirements of a relatively small proportion of its service, used so generally for the movement of all commodities which require protection from the weather? There are several reasons. As the types of cars become specialized and multiplied, the variety of uses to which each may be put will be reduced. This means an increase in the number of cars required, an increase in empty-car mileage, which is already large, and increased difficulties and complications in handling and accounting for the maintenance of cars in interchange. From an operating and maintenance standpoint, the ideal equipment situation would be one in which all freight cars were of a single class and alike in all essential details.

Until after the World War these conditions of inflexibility, based on systematized mass movement, received little attention either from the shippers or the railroads. Since that time, however, conditions have rapidly changed. The railroads themselves in a concerted campaign inaugurated by the American Railway Association in 1923 made great strides in reducing delays in transit, largely in the road movement, and in expediting deliveries. These improvements were a major factor in effecting a tremendous reduction in the amount of working capital tied up in goods in transit, and an equally important reduction in inventories made possible by dependable scheduled deliveries. The railways themselves were therefore responsible for the first modification of the long-established seasonal buying habits which were so well adapted to the large carload and to the delays incidental to the marshaling of cars for movement in long, heavy trains. It is not surprising that, the advantages of the movement of merchandise in smaller quantities on more frequent orders once having been demonstrated, the motor truck on the highway has made heavy inroads into the merchandise traffic of the railroads in both carload and l.c.l. lots because of its adaptability to the overnight delivery of merchandise in small units over distances as great as 300 miles.

MOTOR-TRUCK COMPETITION

Disregarding for the moment the relative cost of the road movement by rail and on the highway, the motor truck has demonstrated a number of advantages over movements of this kind in box cars. Probably the most important of these advantages is flexibility of the service rendered, which can be adapted specifically to the needs of the shipper and consignee. In a study of the shipping situation between New York City and Philadelphia conducted by Russell W. Talbot,[2] in which 15 cases, involving 10 different types of manufactured goods, were studied, by far the most important reason given for shipment by motor truck was the ability to get overnight deliveries. Rail deliveries between New York and Philadelphia may require two to three days. In several cases ability to secure rush service on other than regular schedule was also considered a desirable factor of truck transportation. Store-door delivery, although not considered an essential factor, was found to be a desirable one in most cases. In only two cases was shipping cost an essential factor leading to patronage of motor trucks. Formal packing requirements of the railroads were not an important factor in any of the cases studied.

It is in the l.c.l. traffic and the light-weight carload groups, which together represented 86 per cent of the total box-car loadings in 1929, that the railroads are suffering the greatest disability in meeting highway competition by their present methods. Carload mini-

[2] Strathcona Memorial Fellow in Transportation, Yale University. This study was privately printed for the Committee on Transportation, Yale University, 1931.

mums, based approximately on full use of the cubic capacity of the cars, are becoming too large for the decreasing commercial units which changing buying habits are establishing. A change from carload to l.c.l. lots not only involves an increase in rate, but also adds to the shipper's cost and inconvenience where he is required to deliver his goods to the railway freight house, thereby increasing the advantage of the highway competitor.

DETERRENTS TO CHANGE

The railways have not been slow to undertake the solution of the problem that has thus been created. But they are handicapped by a number of artificial conditions which cannot arbitrarily be overcome at once. Among these are the present freight classification and rate structure, and the restrictions imposed by regulation.

Railway class rates are based on the value of the service, a theory which is still essentially sound in the handling of carload traffic. Unfortunately, however, when the railroads have ceased to be a monopoly and must compete with other agencies and those agencies are free to make any arrangements with individual shippers as to the rates they shall charge for the service they render, successful competition demands that it be possible to fix rates within the zone of competition on a cost-of-service basis. Such a basis in the case of l.c.l. rates would imply a complete abandonment of the class rate structure.

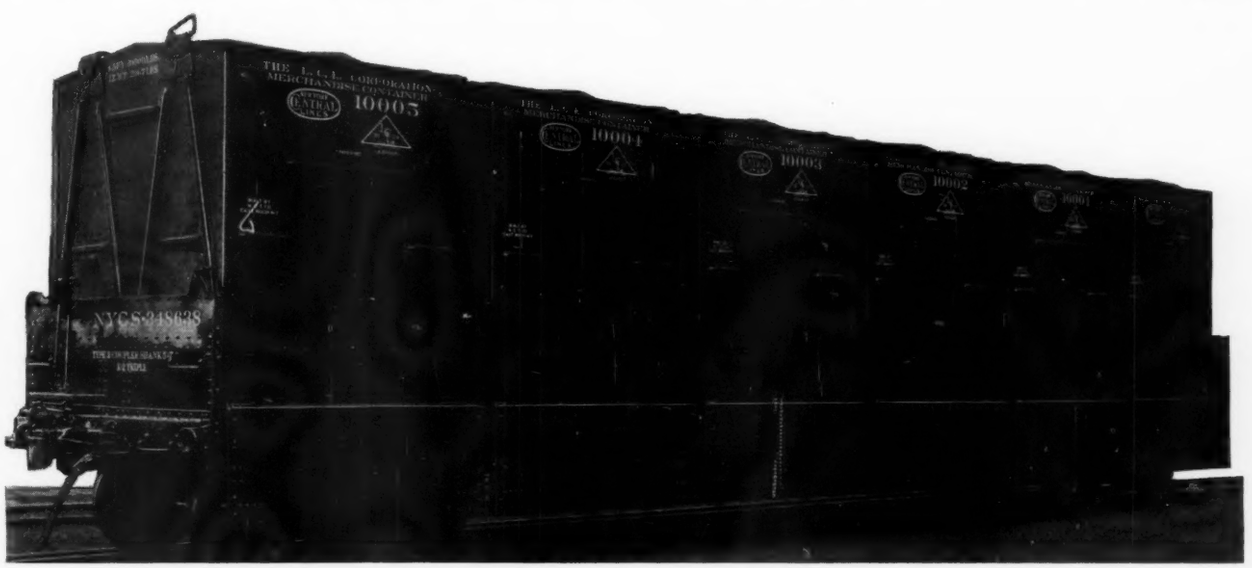
But the speed with which such changes can be made effective is not alone determined by the extent to which forward-looking railway officers are willing to experiment. The Interstate Commerce Commission has jurisdiction over rates and service on all interstate traffic, and the various state railway or public-utility commissions on intrastate service. The basic consideration on which Federal railway regulation was first set up was to prevent the railways, then regarded as a transportation monopoly, from discriminating either as between shippers or localities. Thus, until recently the Interstate Commerce Commission has not been inclined to encourage experimental changes in rates and service which, by their very nature, must be of limited application.

NEW FORMS OF ROLLING STOCK

In any discussion of the effect of new conditions on the future form of rolling stock it is necessary to keep in mind these deterrents to the free play of initiative. They are, however, only deterrents, and much progress has already been made in the experimental development and use of new types of equipment, changes in operation, and simplification of the rate structure in order to cheapen and improve the service to the shipper.

First among these changes in equipment is the demountable container, of which several types are in service. This is essentially a means for providing five or six freight containers on a single underframe instead of a single container, as in the case of the box car. It breaks up the carload into several independent units, which may be collected and delivered intact with a minimum of platform expense or its equivalent to the railroad. The reduced mass of the unit load also provides additional protection against damage from shocks.

There are limitations to the extension of the service of containers of the type now most commonly in use, because crane service must be provided to transfer them between the road and the rail. The investment required to provide crane facilities limits their use to the larger stations. Furthermore, the substitution of containers for box cars in l.c.l. service requires the replacement of l.c.l. transfer platforms with transfer yards equipped



DROP-SIDE L.C.L. CONTAINER CAR. THE DEMOUNTABLE CONTAINERS MAY BE HANDLED BY LIFT TRUCKS OR CRANES. THE DROP SIDES (SHOWN IN OPEN POSITION) ARE USED AS GANGPLANKS

with crane service. The crane time per container to perform the reclassification of containers by destination points places a definite limitation on the number of cars which can be handled through a single transfer yard without loss of a day in transit.

Another modification of the box car is the so-called compartment car, a number of which are in experimental service. In its simplest form this is merely a box car in which the interior has been subdivided by substantial partitions into compartments. Each of these compartments may be used by a shipper under rates similar to the carload rates or a flat container rate, under a minimum similar to a carload minimum, but reduced in proportion to the number of compartments in the car. This scheme offers no improvement in the transfer between road and rail over the box car. It does, however, improve the ability of the contents to resist shock by subdividing the mass, and supplies the need for a smaller shipping unit.

Several railroads are providing a service to truckers which in its physical features does not differ essentially from demountable-container service. Its difference lies in the fact that the container is not furnished by the railroad, and its owner (the trucker) becomes the public transportation agent. The railroad transfers the body from the truck chassis to the car and delivers it from the car to a truck chassis, charging a flat rate based on the container mileage without respect to the contents, except for restrictions against the loading of explosives, unusually fragile goods, etc.

Another scheme in limited use is a truck-and-trailer service which provides for the loading of the entire truck, and its trailer where used, on the railway car. This calls for loading and unloading ramps, the loading and unloading operations being performed by the trucks under their own power. Its use has not been sufficiently extended to indicate clearly its limitations, but it scarcely seems promising for large-scale operations.

These developments have been brought about in an endeavor to reduce shipping units below the size created by mass-transportation tendencies and to find practicable means of coordinating road and rail service. They also indicate an effort to overcome the handicap of the high terminal costs involved in freight-house and transfer-platform expense, the clerical costs involved in billing and accounting, and terminal switching.

Another movement less generally affecting the railways has been brought about by exactly opposite conditions. This is the demand for special cars in which to ship certain dry bulk commodities customarily handled in box cars. The development of central concrete-mixing plants has had much to do with the creation of this demand. So far, it has largely been met by the railroads on which cement shipments are originated by equipping hopper cars with roofs and modified hopper-door arrangements which permit the mechanical loading of cement through hatches in the roofs and its gravity unloading over suitable conveyor hoppers. All sacking and handling are thus eliminated. A special car of the tank type has also been developed which is equipped with a motor-driven unloading mechanism which offers possibilities for the movement of many dry products, including such high-grade materials as flour where it is purchased in quantities for use at large bakeries.

These cars, however, are for use in the movement of bulk commodities, and each represents a specialized shipping problem. The big problem which is yet unsolved is the development of types of equipment adapted to the handling of that vast group of miscellaneous products which in 1929 called for the loading of 24,000,000 out of the 28,000,000 box cars loaded—the groups of commodities in which highway competition is making its greatest inroads.

THE FUNDAMENTALS

In pointing out the advantages of the trucks in performing a complete transportation service in this field, the question of the relative cost of the road movement by rail and on the highway was disregarded. No attempt will be made here to discuss this question in detail. It has for some time been a highly controversial subject and one that involves a question of public policy which cannot be satisfactorily settled until the basic facts are established. Fortunately, these facts are rapidly becoming clarified. It is sufficient for the present purpose to point out that its ultimate settlement will exert a decided influence on the way in which road and rail transportation will ultimately be coordinated. Present indications lead to the belief that the settlement will be on a basis fair alike to the taxpayer, the railroad, and the user of motor vehicles.

Under that assumption there will be a situation in which the fundamental conditions are as follows:

1 Stripped to its essentials, the use of mechanical power in large units on modern tracks is the cheapest form of land mass movement.

2 A complete rail-transportation service, in the l.c.l. class and in the case of some carload traffic, involves road haulage.

3 The economic coordination of road and rail service involves the use of the cheap rail haul with road collection and delivery service.

4 The radius within which highway transportation will successfully compete with the railroad to secure the complete movement from shipper to consignee will depend upon the relative degree of flexibility of collection and delivery by highway or by rail and highway, on the cost of the transfer between road and rail, on the relative simplicity of packing requirements, and on the attractiveness of business relations involving the rate structure, settlements for loss and damage, etc.

At present the railways are handicapped by their system of freight stations with high platform and clerical costs, by the inflexibility of a service organized essentially to fit the operating requirements of the mass movement of commodities in carload lots, by equipment designed to withstand shocks which are destructive to the lading unless expensively protected, and by an unattractive rate structure.

Two problems of equipment design are involved: one strictly a problem of the railway industry and the other, in its broadest sense, a problem of material handling. The railway problem is to eliminate the destructive effects of the current rough handling. The St. Louis Southwestern in a move to meet truck competition in its territory has inaugurated an overnight l.c.l. service between St. Louis and points as far south as Texarkana, Ark., and Shreveport, La. This road is operating a train of 20 to 25 cars which requires an overall schedule speed of 40 mph. Other railroads are operating full-tonnage trains on schedules approaching passenger-train speeds. Improvements in freight-car trucks of the type suggested by the late T. H. Symington[3] are effecting great reductions in the vertical shocks which build up at certain critical speeds with the conventional spring arrangement. Improvement is needed in the cushioning of end shocks. This may require the adoption of passenger-car standards in cars used for certain merchandise shipments to be handled on passenger-train schedules if the rigid, costly packing requirements of the present l.c.l. classification are to be ameliorated.

Modern material-handling methods have already served the railways in the handling of l.c.l. freight in the form of warehouse motor trucks and trailers. But this is not enough. The motor truck, once loaded, moves to its unloading point without further handling. When the rail link is interposed between motor-truck hauls from the shipper at one end and to the consignee at the other, a complete rehandling at each end of the rail movement, no matter how efficiently it may be performed, limits the extent of the use of low-cost haulage by mechanical power on rails. This should be eliminated to the fullest possible extent, and railway equipment will be changed in form, if necessary, to adapt it to the cheapest form of handling.

As the types of equipment are multiplied, the problem of empty-car mileage will become more acute. So far as this affects the design, it will increase the pressure for lighter construction. This is already beginning to receive attention on the part of equipment designers. Any probable increase in expense from this cause, however, would be small in comparison with the reductions in expense which can be effected by the elimination of local freight houses with a coordinated road and rail service, in which the radius of the road movement is kept within the limit of its economic advantage, and such handling of freight as is necessary is concentrated at a few well-placed and well-equipped stations. The taxes on the high-priced land occupied by some local freight houses in city areas amount to more than the revenue they originate.

The solution of these problems requires the utmost ingenuity of the railroads, which need and ultimately will use all of the practical assistance offered. Whether, and how, they are solved is not alone a matter of interest to the railways and competing highway-truck operators. The rate structure in America has been built up on the basis of the value of the service. Commodities of high value take a high class rate. Commodities such as coal, iron ore, sand and gravel, and the low-priced tonnage products of industry carry low rates which permit their movement over long distances to widely spread markets. Railroad losses of high-rate merchandise, which produces large revenue relative to the cost of the service, jeopardize their ability to continue to transport the important raw materials and intermediate products of industry, low in value in relation to their weight and bulk, at the low rates which have been a large factor in making our industrial growth possible. How these problems are solved, therefore, will exert a profound influence on the future economic life of this country.

[3] "Research Relating to the Action of Four-Wheel Freight-Car Trucks," by T. H. Symington, Trans. A.S.M.E., 1930, paper RR-52-9, p. 109.

NEW SELF-UNLOADING DRY-COMMODITY TANK CAR FOR TRANSPORTING ABRASIVE MATERIALS, SAND, CEMENT, AND MANY FOOD PRODUCTS

PUBLIC WORKS AS A STABILIZER

By E. OGUR[1]

FOR several years prior to the beginning of the present depression, earnest students of economics advocated the use of public works as a stabilizer Public works, they argued, constitute a considerable portion of all construction. Carried out during the peak of the business cycle, they aggravate the shortage of labor and materials, resulting in increased costs of *all* types of construction. Deferred until the valley of the business cycle is reached, they will be instrumental in reducing the acuteness of unemployment and will maintain a more uniform level of prices of labor and materials, which will result into vast savings to the nation, in addition to maintaining a business-cycle curve with lower peaks and shallower valleys. It all sounds logical enough.

During the early months of the present depression men in public life seized upon the idea and took the various branches of Government administration to task for not getting ready the necessary plans and specifications fast enough so that people could go to work. Various suggestions for accelerating the preparation of such plans and specifications were made, the most important one being that a Department of Public Works be established, this department to have charge of the planning and control of public projects, and to prepare plans and specifications for such projects during the peak of the business cycle and have them ready for immediate release for execution as soon as the business curve shows appreciable signs of downward movement. The idea has received the approval of the engineering fraternity, and with legislation therefor pending it is only a question of time when it will become a reality.

It is a fallacy to limit the discussion of public works only to projects by the Federal Government. It is folly to expect the Federal Government to undertake any considerable number of projects because of the extremely limited scope of its activity. In normal times most of the public works, such as schools, hospitals, water works, sewage systems, incinerators, court houses, fire houses, police stations, parks, roads, bridges, etc., etc., are carried out by municipal, county, and state administrations. The cumulative effects of these projects are vastly greater and more effective than such outstanding Federal projects as the Boulder Dam. And therein lies the chief difficulty.

Village, municipal, county, and state governments have no reserve funds upon which to draw. Their budgets are made up at the beginning of the fiscal year and the tax rates fixed accordingly. Frequently they have to resort to short-term borrowing to meet their current expenses while tax collections are lagging, a very simple banking transaction in normal times. Any expenditure of a capital nature has to be effected by means of funds raised through bond issues. These bond issues have to be voted upon by city commissioners, city councils, or other bodies, or submitted to a referendum after hearings of the proposed ordinances or enactments for the execution of the given project have been held. If approved, the bonds are issued and sold to investors, usually banks or bank syndicates.

In normal times, that is, when confidence prevails, no difficulty is experienced in passing ordinances for the execution of projects, even if they are of questionable value to the taxpayer. The piling up of obligations on the future generations seems to worry few. In fact, the great majority of public improvements in normal times are undertaken upon taxpayers' petitions for projects such as the paving of streets, building of schools, installation of storm sewers, increasing of water pressure, planting of shade trees, replacing of obsolete garbage-collecting trucks by modern sanitary noiseless equipment, etc., etc.

But in times of depression, that is, when confidence is impaired to a point bordering on panic by the mounting number of unemployed, a large percentage of whom are in desperate circumstances, by the staggering number of bank failures, business bankruptcies, foreclosures, etc., we are confronted with a condition which forms the crux of the subject under discussion and which has been overlooked by advocates of public works as a stabilizer.

Under those conditions it becomes next to impossible to secure a favorable vote on, or prevent an organized minority from blocking, the undertaking of a construction project, however imperative or desirable. When favorable action is secured, it is next to impossible to sell the bond issue even if the rate of interest is double that in good times. Where eight to ten bids were received in 1929 for bond issues yielding $3\frac{1}{2}$ per cent, none were received in 1932 in cases where the yield was 6 per cent.

In the field of quasi-public work, such as endowed colleges, churches, community centers, fraternal club houses, athletic clubs, etc., conditions are practically the same. When times are good no difficulty is experienced in raising funds by selling bonds to the members, by endowment subscriptions, by testimonial dinners at $250 per plate, by souvenirs at $100 each, etc., etc. But any such attempts made during times like the present would be doomed to failure.

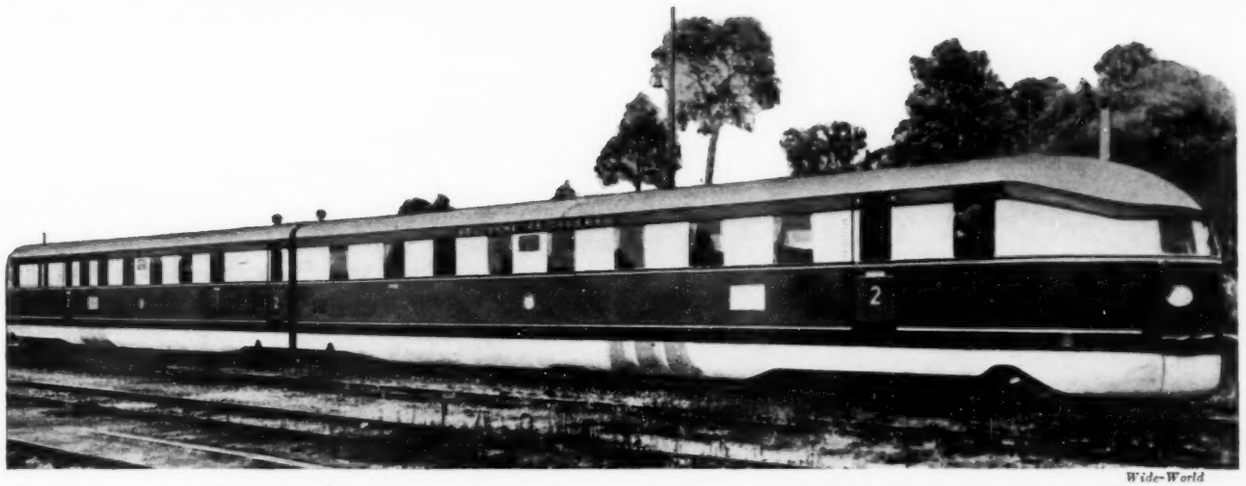
Consequently, during good times when there is a scarcity of labor and materials, municipal, county, and state works, as well as semi-public projects, are in full swing. When business slows down, public and semi-public projects come to a standstill. Thus public works instead of being a stabilizer are in reality a disturber, giving the business cycle a swing of greater amplitude, and for no other reason than the *method of financing*.

Yet public and semi-public works *could and should be* used as a stabilizer for the benefit of every one concerned, reducing the "feast" during normal times and preventing the "famine" during those like the present. It may not be a simple matter to accomplish this, but it is not impossible—not for the engineer!

It is idle to discuss the "creation of work," the acceleration of the "preparation of plans and specifications," etc. when there are so many projects of an imperative nature for which plans and specifications were ready two or three years ago and contracts were awarded more than a year ago but which have been deferred or abandoned for lack of financing. It is a subterfuge unworthy of the engineer.

The problem reverts again to the "simple" proposition of *devising means for financing* public and semi-public projects during times when banks need their cash for meeting withdrawals and cannot buy bond issues. It is the writer's conviction that the engineer is fully capable of solving the problem once he applies himself to it.

[1] Consulting Mechanical and Electrical Engineer, Newark, N. J. Assoc-Mem. A.S.M.E.



Wide-World

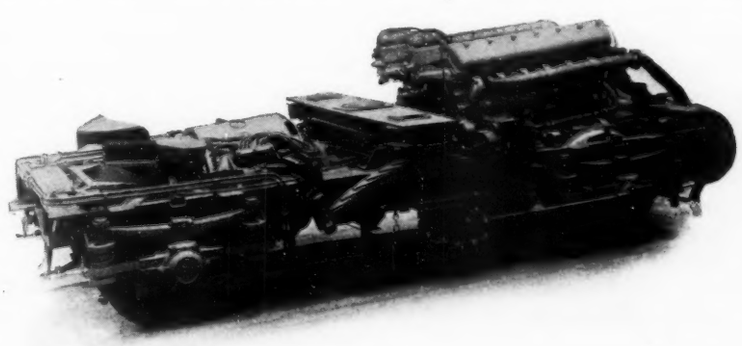
NEW HIGH-SPEED DIESEL-ELECTRIC CAR OF THE GERMAN STATE RAILWAY

Future Design of PASSENGER EQUIPMENT

By C. E. BARBA[1]

THE main object of this paper is to stimulate the imagination and activities of those engaged in the design, manufacture, and operation of passenger cars in connection with the possibilities that lie in the development of designs capable of reducing some of the present maintenance costs and increasing the efficiency of manufacture. To what extent light-weight equipment is to be developed for future use depends entirely upon the quantity and disposition of the present equipment. The design of today and that of the future must be treated separately and not in combination, and this excludes interchange with connecting lines and thereby complicates train "make-ups." Likewise, light equipment must operate in solid trains, as a few cars could not be handled except on the rear of present trains, which is certainly not desirable. The problem therefore is one of evolution of our present transportation structure, and can only change whenever a real necessity demands a change in the present facilities.

It is undoubtedly true that less effort has been expended in experimentation and in the development of freight and passenger cars than in competitive fields such as those of electric interurban street railways, automotive buses and trucks, and last but not least, airplanes and dirigibles. This is largely owing to a division of responsibility between the railroads, car builders, and supply companies, since car construction to a great extent makes use of available patterns and dies for pressing of underframe and superstructure members and specialties already in existence. The design of equipment under such conditions is comparatively simple, since the engineering principles have been fairly well established. To establish a precedent in car design calls for the combined efforts of the railroads, the supply industry, and



Wide-World

TRUCK OF CAR SHOWN AT TOP OF PAGE

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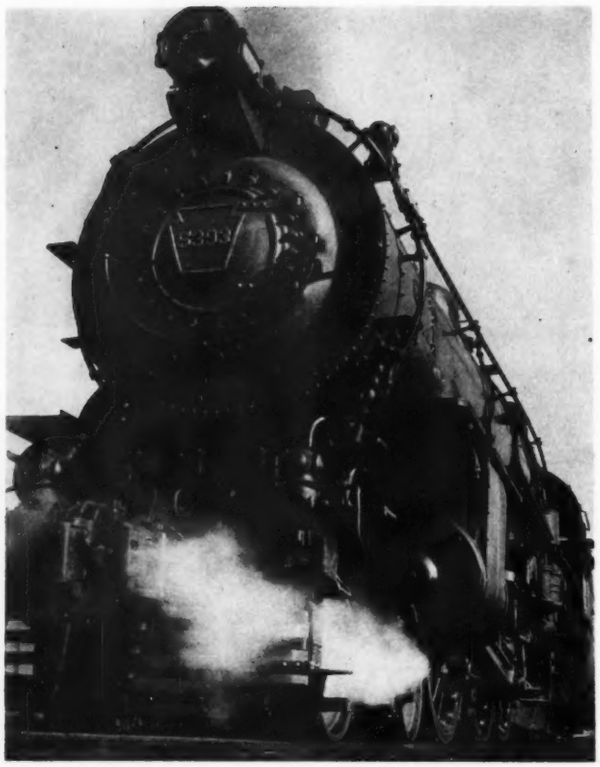
Contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., December 5 to 9, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



the car builders, and a design should be developed to suit present-day demands, eliminating the adaptation of past developments whenever they may conflict with the advancement of the art. This calls for maximum strength and convenience, combined with minimum weight and a general reduction of the initial cost through mass production.

LIMITATIONS IMPOSED UPON DESIGN

To secure a satisfactory basis upon which to formulate our theories, it is first necessary to ascertain the demands of the service for which the vehicle is intended, and then form a conception of the resistance and destructive forces which must be overcome in order that it may satisfactorily perform its desired function. The problem is complicated by sharp limitations, such as those of lightness, economy, and reliability.

Lightness. From a weight of 375 lb per passenger in 1836, the draw load has increased to 1800 lb for coaches and from 4000 to 5000 lb for some of the modern cars forming part of our de luxe trains. The present weights were largely arrived at in an endeavor to secure a closer approximation of uniform train strength, when combined with the later weights. This policy, although sound with respect to the existing equipment, nevertheless forbade the use of lighter-weight equipment whenever interchange of cars became necessary.

There appears to exist a general lack of knowledge relative to the strength of light-weight equipment as compared with that of the present equipment. Kinetic energy stored up in a moving mass is measured in foot-pounds and is a function of the speed and total weight of a train. If a train is brought to rest in too short a time, the result is usually a crumpling up of vestibules and platforms and a disalignment of equipment. The action is similar to that of a pile driver, as the kinetic energy stored up in the drop of the "tup" produces a blow on the head of the pile, the movement of which is dependent on the resistance encountered and which can only come to rest when these two factors equalize. This principle therefore permits the development of a light-weight design that will have a strength factor equal to those now employed, provided it be confined to trains of like weight.

Economy. This includes initial cost, cost of maintenance and repair, and cost of transportation. If maintenance, repair, and depreciation costs are kept to a low figure, the long life of steel cars will make them economical, even at an increased initial cost. Transportation costs are concerned with the proper design of car body and trucks to give the least haulage resistance, the proper design of coupler and coupler clearances, and, in general, the vibration of the car, which directly influences travel. Likewise, excessive weight affects the cost of haulage unless the total load is within the capability of the prime mover. This seems to be true so long as we neglect the factor of speed. Rapid acceleration and retardation demand the lowest weight consistent with comfort and safety.

Reliability. Safety and strength with economy are the ends sought. These are usually obtained by the introduction of load-carrying side members, supported by an underframe capable of sustaining end shocks commensurate with total train weight, a roof construction that will sustain the weight of the car body, and an end construction that will resist telescopic action. The ideals, therefore, to be considered in future car design would seem to be somewhat as follows:

IDEALS TO BE AIMED AT

Trucks. Of the multitude of designs put forth, none have departed in principle from the design of the wooden truck used prior to steel equipment. That riding qualities are of unusual importance is evidenced in the design of competitive transportation facilities now offered at no increased cost to the traveling public. The query therefore arises as to whether any improvements are possible in existing designs, or whether we should depart from present practices and inaugurate new principles that will more nearly fulfil the trend of automotive practices.

Since draw weight is an important factor in the final determination of the motive power selected, it follows that the proportion of truck weight to car-body weight is very much in excess of what it should be. That designs move in cycles is apparent, as the early designs of frame and bolster were built up of plates and pressings. Later these were replaced by steel castings, thus creating a more homogeneous unit, but at the expense of increased weight due to the materials used.

Weight is therefore a function of the materials used,

and the designs drafted for its most economical distribution indicate that we have not taken advantage of some of the metallurgical developments of recent years in utilizing a material that is capable of sustaining loads at a working stress of 25,000 lb per sq in., thus saving approximately 36 per cent for all cast-steel details. On the other hand, since cycles move backward as well as forward, there may be the possibility of again reverting to pressings by utilizing some of the stainless-steel plates and shapes, which opens up an entirely new field in methods of construction embodying forms of welding made necessary due to the character of the material.

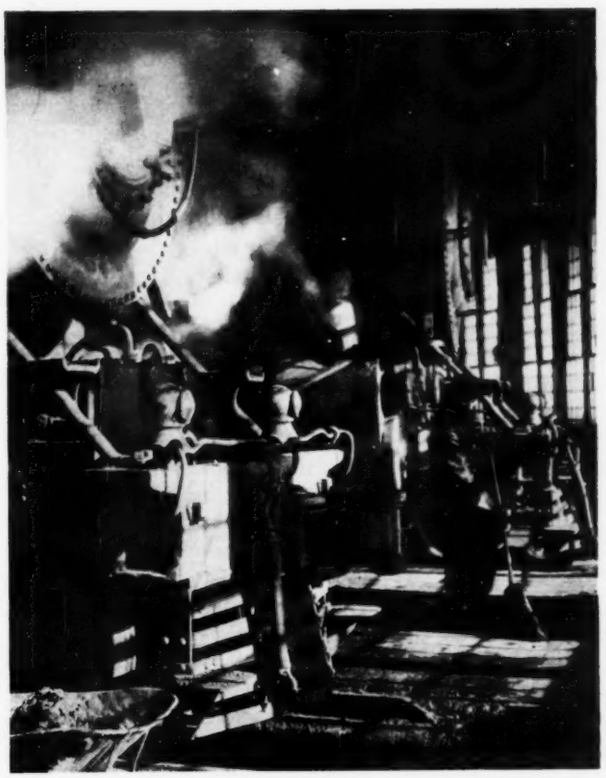
As wheels and axles contribute largely to the weight factor, and as roller bearings of varying designs are available, it would seem rational to consider a design of truck based upon automotive principles, in which lightweight wheels, having extended hubs for brake-band application, are made demountable, attachment being made to a fixed drop-forged axle. Such a design would eliminate the present forms of spring-frame members and enable the use of semi-elliptical springs in combination with helicals and a suitable design of shock absorber. The rotation of our present trucks relative to the horizontal axis of the underframe is very necessary, due to the wheel mounting employed. Individual wheel mounting, however, eliminates truck separation and provides permanent attachment of the spring arrangement to the stationary axle forming part of the car structure. Rough riding is not wholly due to spring action, since clearances, ofttimes excessive, between journal box and pedestal, between bolster chafing plates and transom fore and aft, and the amount of lateral clearance between journal boxes and pedestals, including that of brass on journal, more or less aggravate the case in starting as well as in retardation. The elimination of these factors is worth while. Such a design of wheel arrangement would lend itself admirably to the construction of high-speed, direct-drive, streamline units for competition with bus traffic, as well as of coaches for steam operation.

Underframe. In the underframes of present equipment, load transference is effected in two ways:

a No bolsters are employed. The static lading is all transferred at various intermediate points to the center sills, which in turn places it directly upon the center plates which are riveted to them. This method presupposes a strong center sill and may make use of a weaker side girder.

b All sills carry load to a bolster. This method is characteristic of a majority of all equipment in service.

The first method lends itself particularly to those cars which have side doors, such as the postal and baggage types. A support may be placed directly under the aperture for load transference to the center sills, and the side will not need to be strengthened by a framed construction carrying the load up to the eaves and over the door. The underframe member should be standardized by designing for the maximum length of the car, and when shorter cars are required a central unit may be removed and, when advisable, the thickness of



cover plates reduced, having the sills remain constant in cross-section. The riveting can be anything that is consistent with good design, but in the central unit section it must be a constant function of the distance between posts, so that the removal of such a unit will not alter the spacing.

The underframe should be designed with a view to the clearance required for both steam and electric service, and all auxiliaries be so located that a change in service will require but a minimum of alterations. Also some consideration should be given to transverse load-carrying members in order that all present heating coils now located on each side of a car may be dispensed with and the heating radiation be placed under the floor in plenum chambers connected with suitable ducts for the purpose of providing universal air conditioning in all seasons. For lightness, the present form of center-sill construction is not essential, provided that all end shocks can be uniformly distributed to longitudinal members securely tied together for maximum transverse strength, which construction would lend itself more favorably to heating and air-conditioning arrangements.

Superstructure. Here one may adopt a section between side posts comprising one window opening as a unit, and thereby obtain various lengths of cars by the addition or elimination of these units. Side sheets to run from bottom of the side sill to the top rail, having the window opening (rectangular) pressed inwardly with projecting flanges for the support of the inside finish. The vertical edges to be flanged inwardly and to abut each other, thus forming part of an interlocking post

and carline construction. Window frames to be of metal, incorporating two glasses per sash, spaced approximately $^3/_8$ in. apart, the air space thus provided to act as an insulation for seasonal variations in temperature, as well as to increase the efficiency of air conditioning. All sash to be flush with the exterior surface of the car and permanently applied to the side sheet.

The belt rail of necessity must be transferred to the back of the side sheet by applying it in pressed recesses in the side posts. Such an arrangement would permit of the procurement of single-length side sheets to cover one window spacing. This feature has a twofold purpose, namely, to eliminate buckles in side sheets covering two or more window openings, and ease of repairs. The form of roof best adapted for strength, lightness, and ease of repairs is one of a semicircular construction. U-shaped car lines are preferable, with aluminum sheets to conform thereto, provided more attention is paid to proper insulation, as this feature will become an important factor upon the general adoption of air conditioning.

Furthermore this form of roof necessitates some modification of the interior decorative features relative to air ducts and indirect lighting features, in themselves an innovation and altogether possible. This therefore precludes the elimination of the clerestory, sash frames, sash, screen, ventilators, deck plate supplementary carlines, and inside moldings, all of which decreases weight and assists maintenance.

A further desideratum is the adoption of a standard end, including platform and vestibule, simplifying the anti-telescopic features and increasing its effectiveness by transferring more load to the side members. To facilitate a more rigid end construction, it is suggested that the present form of hood construction be eliminated and the semicircular roof be continued to the end of the vestibule, which would decrease the wind resistance, simpify construction, and reduce the cost.

Since the general contour of present-day equipment is a replica of our former wooden equipment, we welcome such contributions as "Air Resistance of High-Speed Trains and Interurban Cars," presented before the Society last year by Dr. Tietjens and Mr. Ripley. The paper as a whole presents very many interesting results and leads the way in the development of single high-speed units for through service where density of population calls for such service rather than bus transportation. Relative to streamlining an entire train, some consideration must be given to the type of train to be considered, of which the following are typical: (*a*) steam locomotive, express service; (*b*) electric locomotive, express service; (*c*) multiple unit, express service; (*d*) single unit, gas-electric, Diesel-electric, and mechanical drive, express service; (*e*) interurban, electric, express service.

From the foregoing it is apparent that a series of cars coupled together presents a most difficult streamlining problem in bridging the gap between cars since the present clearance between vestibule corner posts or end sills is necessary for curving. Thus far, no progress has been made in developing suitable flexible connections between cars other than the present diaphragms, which usually are a source of annoyance and maintenance.

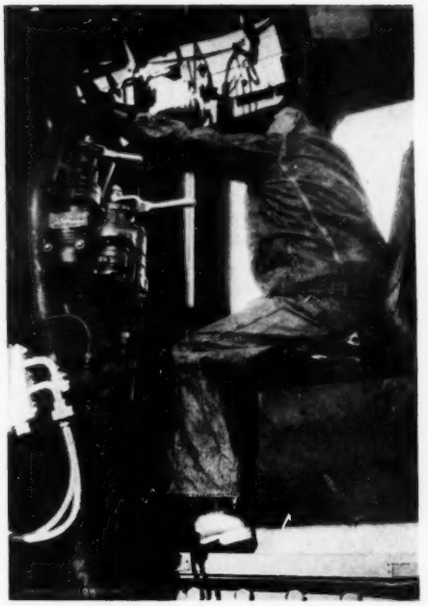
Let us therefore consider a new form of connection between cars, based on the hinge principle, that is, have the end of one car convex and the other concave, and the width of passage openings increased so as to maintain at all times a standard width at maximum curvature. Such a design would eliminate the present diaphragm and plate with its supports and permanently close the gap between cars, thereby providing a smooth exterior for the entire train.

Interior Finish. Theories have been advanced that the ethics of the service demand an all-steel car, although the last 27 years have demonstrated that all-steel cars may be modified to the extent of using wood in some form for inside finish without destroying the advantages that they offer as a measure of safety. The present form of steel inside finish involves considerable labor for its application, necessitates lining for heat insulation, and adds nothing to the strength of the car body as a whole. It is therefore suggested that the interior design be modernized to the extent of utilizing a composition lining, fireproofed, and that moldings for architectural purposes be developed having a contour that will lend themselves to this form of manufacture. Recent developments in the field of interior decoration have produced a system whereby it is possible to apply, by means of transfers, actual reproductions of famous wood paneling at a reasonable cost, which besides possesses wonderful wearing qualities when applied to either steel or composite lining treated with the usual varnish finish, either bright or dull.

Insulation. Another need is the development and standardization of an insulating material and method of attachment that will insure stability and long life for a minimum weight. Preferably insulation should be applied like wall paper, that is, each part in intimate contact with the detail it is supposed to insulate. This subject is still an open question as regards material and methods of application, as is evidenced by the variety of installations now in existence. Further study is suggested, for air conditioning has brought up new questions

that require some recognition in the interests of efficiency.

Air Conditioning. The subject of ventilation and the comforts to be derived from an efficient circulating system have long been considered. Without reviewing the various systems so far developed, it suffices to say that the present systems were largely designed to fit spaces available and are at best makeshifts from an engineering standpoint. This feature should be recognized in the design of new equipment, in order that a system may be developed that will form part of the car structure. This therefore calls for two designs, one for present equipment and one for new equipment. Any system adopted should be a dual one; that is, for both summer or winter use, with automatic control provided for both systems.



Saloons and Lavatories. The cost of manufacture of enclosures of this character when made of steel and adhering to the finish required as part of the interior arrangement is not consistent with productive methods now in vogue. A standard saloon and lavatory can be designed for all coaches embodying all of the latest appointments, including switch lockers and water coolers, and for sanitary reasons should be made of stainless steel, and so designed as to permit mass production.

Seats. Comfort should be the keynote in the design of this equipment. All previous designs have been limited by the height of the steam-heating system and the window sill from top of floor, which indicates that the design may have been influenced by specialties over which the designing engineer had no control, or else a lack of cooperation between the designer, manufacturer, and specialty company. The type and style of furniture developed in recent years have clearly demonstrated that comfort is demanded of the manufacturer, and it would therefore seem reasonable to expect similar convenience in vehicles of transportation, which therefore should be our guidance in all future development.

Painting. Generally speaking, the painting of steel passenger equipment forms a subsequent source of expense in maintenance and cleaning processes between shoppings, all of which can be eliminated by the utilization of stainless-steel sheets for sides, ends, and vestibules, including side and end doors, the roof having been previously mentioned. Such cars have been built, and the data available indicate a tremendous saving in maintenance.

Lighting. Present arrangements leave much to be desired, and in the interests of economical operation the author would recommend the development of a Diesel generating set, located transversely in an extension of the tender, having a semicircular roof to conform to the car roof, side windows, and end door, and that each passenger locomotive be so equipped, the cost in the aggregate being less than that of the combined facilities now in use, and the conduit system for wiring purposes much simpler.

Draft Gears. The development of present capacities is predicated upon the type of equipment and service intended, and although rules, regulations, and specifications covering the conduct of tests desired have been helpful, the limiting restrictions of center-sill spacing have been a real stumbling block in the advancement of the art and should be modified, since efficiency of gear operation is a function of time elapsed between cycles of compression, whether negative or positive. Since the design of draft gears, their manufacture, and the tests prescribed have become a specialized field, it would only seem proper that the manufacturers develop what they consider the ideal draft gear, after which the sills and other underframe members could be designed to suit.

Air and Steam-Heat Connections. The present system of conducting air and steam from one car to another through the medium of hose and couplings has received more than ordinary attention in recent years, due largely to increased train lengths. The main issue seems to be one of material and design, and although no definite standards have been adopted, various designs are being tested, indicating the gradual evolution of a very old standard. Can they be eliminated in their entirety?

The success of any equipment depends upon the design, but, unfortunately, the lack of time usually available between the starting of a design and the placing of an order has seriously hampered the designer. It is unfortunate that the managements do not usually foresee the difficulties involved in such a problem and grant at least a year for the development of a design which will not only be satisfactory for the initial order, but from which future orders of cars of different lengths and character can be constructed more expeditiously. The research work necessary to determine the possibilities of an all-steel equipment as regards ease of manufacture and maintenance is enormous, but undoubtedly the labor thus spent is more than balanced by the decreased cost of maintenance and interchangeability.

The ideal car will never be built, but a lighter car, of simple and easy, though sturdy, construction, that will carry the greatest number of passengers most comfortably on the least number of bearings, and will always be ready to serve, is the type of car desired. It is hoped that the various suggestions made in the foregoing may serve as a guide toward such a development.

LARGE PRESSURE TANKS FOR OIL-GAS STORAGE

By L. S. STILES[1]

EARLY in 1931 two pressure tanks were installed at the Greenpoint Plant of The Brooklyn Union Gas Company. These huge receptacles are for the storage of refinery oil gas employed in the refinery-oil-gas reforming process for gas enriching.

The American Society of Mechanical Engineers has a code for unfired pressure vessels, which of course, would apply to tanks of this type. This code differs in certain details from the commercial practice of manufacturers of pressure tanks, and naturally is more exacting. The question therefore arose as to whether these two tanks should be designed and constructed according to commercial practice or according to the A.S.M.E. Code.

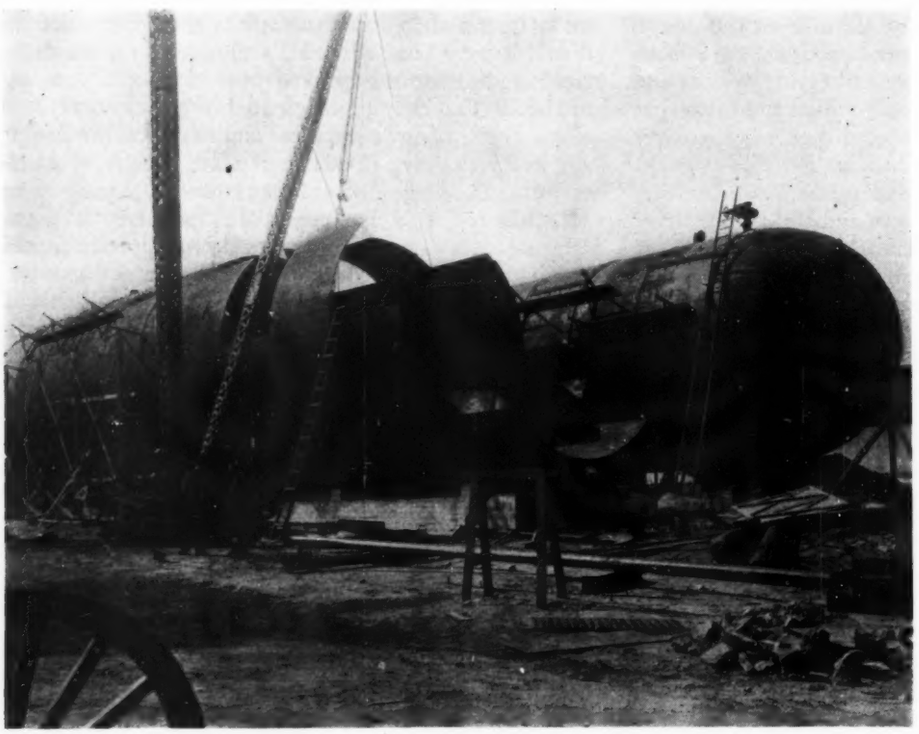
The company, in line with its consistent policy, desired to follow the best standard of practice within reason, and although the State of New York, which can at any time it sees fit standardize the construction of pressure tanks, has not done so to date, if it does assume such jurisdiction at a future time and adopts the A.S.M.E. Code, which would be the natural criterion for it to use, the permissible pressure at which these tanks could be operated might be reduced by the state authorities if the tanks were not constructed in accordance with that code. This of course would seriously affect the storage capacity of the tanks, and might prove embarrassing.

Under these circumstances it seemed better judgment to conform to the A.S.M.E. Code in the design and construction of these tanks, with the exception that instead of testing the tanks with hydrostatic pressure double that for which they were designed, they were tested with air up to a pressure of about 72 lb per sq in. A hydrostatic test for tanks of this size is wholly impracticable.

The author went exhaustively into all matters as to design, characteristics of test, etc. with a number of engineers intimately familiar with the subject, including officers of the A.S.M.E., E. R. Fish, Chairman of its Subcommittee on Unfired Pressure Vessels, and C. W. Obert, a member of that Subcommittee in an advisory capacity.

The tanks are designed and built to store gas up to a pressure of 50 lb per sq in., and each has a capacity of 150,000 cu ft at 50 lb pressure and will discharge 300,000 cu ft of free gas from 50 lb down to atmosphere. They are 23 ft 4 in. in diameter by 110 ft $7\frac{1}{2}$ in. long, and are carried on two reinforced-concrete girders with reinforced-concrete cross-beams, and supported on concrete pedestal piles. There are six cradles supporting each tank, one of them being fixed and the others carried on rollers to allow for expansion. The cylindrical portion of the shell is of $\frac{11}{16}$-in. plate, and the two hemispherical heads are of $\frac{1}{2}$-in. plate. At each point of support there is an internal spider to support the shell when there is no internal pressure. This spider is attached to the shell at only one point. The longitudinal joints in the cylindrical shell have butt straps. All joints are riveted throughout. The rivet holes in the heads and butt straps were punched and reamed to $\frac{1}{4}$ in. diameter, and those in the shell plates were drilled and reamed to $\frac{1}{8}$ in. diameter. The plates for the hemispherical heads were formed hot. All steel conformed to A.S.M.E. specification S1 for steel boiler plates, 55,000 to 65,000 lb tensile stress.

[1] Construction Engineer, Brooklyn Union Gas Co., Brooklyn, N. Y. Mem. A.S.M.E.



TWO 150,000-CU FT STORAGE TANKS DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH A.S.M.E. CODE FOR UNFIRED PRESSURE VESSELS

DUST *in* INDUSTRY

The Economic and Hygienic Aspects of Silicosis

By ALBERT E. RUSSELL, M.D.[1]

IT WOULD be difficult to estimate with any degree of accuracy the number of people in the United States who are engaged in dusty trades; in fact, with the present varied record systems of the different states, such an estimate would be practically impossible. This the author learned when he was preparing his paper for the International Silicosis Conference. However, an idea of the frequency of exposure to dust may be found from the statement that more than half a million workers are engaged in the coal-mining industry in the United States, and over 20,000 workers are employed in dusty occupations in New York City alone. It is evident that more people are exposed to dust, which constitutes the greatest single industrial hazard, than is generally supposed. Certain dusts contain poisonous elements, such as lead, arsenic, mercury, etc., which give rise to general conditions resulting from their absorption. This paper, however, will deal only with those dusts which are known to be direct factors in the production of pulmonary diseases.

Dust is possibly the oldest source of industrial hazard. Knowing as we do how dust is generated, we may assume that as far back as the stone age and farther, people have been affected by it. Certainly the Greeks, Romans, and Egyptians must have encountered this hazard in connection with their extensive construction work with stone. The harmful effects of dust are mentioned in Greek literature, but the Italian writer, Ramazzini, gave us in the 18th century the first detailed account of the action of this industrial factor upon the worker.

ECONOMIC ASPECTS OF SILICOSIS

The economic problem presented by silicosis is tremendous. The suffering and loss of life due to it cannot be adequately measured. In the gold-mining area around Johannesburg, South Africa, during the period 1911 to 1929, £11,208,015, or more than $53,000,000, was paid in compensation alone. The costs of medical care, hospitalization, and legal proceedings further augmented this enormous figure.

Mines in Australia are reported to have been bankrupted by payment of silicosis compensation. The author knows of a company in our own country which has claims amounting to more than a million dollars for disability due to dust inhalation. There are other plants in the East which will be bankrupted if all the claims which are filed against them are allowed. In most of the industrial states the number of claims filed has greatly increased in recent years.

It is clear that dust-prevention work, like any health-promoting activity, would pay many times its cost in money, good health, and efficient operation.

Strangely enough, only during the past 25 years has dust received much attention as an etiological factor of disease. The rapid development of industrialization within that period partly explains the impulse toward the study of this source of industrial hazard. The advances which have been made in all branches of industrial medicine have helped to center attention on dust and its effect upon the health, inasmuch as the number of workers in the dusty trades is larger than that of any other group exposed to a single industrial hazard; and an additional reason for increased interest in this subject is gathered from the study of mortality statistics, which reveal the fact that workers in the dusty trades have an excessive death rate from tuberculosis, as well as from other respiratory diseases.

The most notable studies of silicosis have been made in the gold mines of South Africa, where the disease, with its complications, has been most commonplace among the miners. It became necessary either to study the disease and devise methods for its control or else to abandon mining. Consequently funds, personnel, and clinical material were made available for the first time on a large scale. Investigators in South Africa have become foremost in this field of research; their scientific work is widely known and has served as a basis for legislation, compensation rates, and further study of the disease silicosis.

There are almost 300,000 workers in the South African mines. It was because of the excessive incidence of silicosis among the miners around Johannesburg that the International Labour Office of the League of Nations selected that city for the first International Silicosis Conference.

In the United States the first study of the effect of dust was made by Dr. A. J. Lanza, an officer of the Public Health Service serving with the Bureau of Mines. His observations, made on miners in the Joplin, Mo., district and published by the Bureau of Mines and Public Health Service, have been confirmed by subsequent studies. Agencies which have done and are now doing investigative work are the U. S. Public Health Service, the Bureau of Mines, and the Universities of Harvard, Yale, and Pennsylvania. Private persons have also contributed valuable information on silicosis.

The word "pneumonoconiosis" is of Greek origin

[1] Surgeon, U. S. Public Health Service; Chief Surgeon, U. S. Bureau of Mines, Washington, D. C.

Presented at the National Process Meeting arranged by the Process Industries Committee of the A.S.M.E. and held under the auspices of the Buffalo Section of the Society, Buffalo, N. Y., June 6 to 8, 1932.

and means "dusty lungs." It is an inclusive term and is being used now more than previously with a designation as to the type of dust responsible for the pathology. There are few instances where a pure dust, i.e., one unmixed with other elements, occurs in industry.

The intelligent consideration of the relation of dust to the etiology of pulmonary disease must include the following:

1 Chemistry and petrography of dust
2 Condition of worker at beginning of exposure
3 Length of exposure, concentration, and size of particles
4 Effects produced.

The dusts most frequently met with—and, incidentally, the most harmful—in the industries are inorganic. It has been shown conclusively that silica, one of the most common dusts encountered, alone produces more permanent pulmonary damage than all other causes combined.

CHEMISTRY AND PETROGRAPHY OF DUST

In the earlier days all dusts were thought to be capable of producing serious damage. Subsequent investigation showed that this was not the case, and that no two types of dust produced the same results. Clinical and experimental work has proved that silica is the arch-offender. Therefore any paper on the subject of pneumonoconiosis must necessarily be concerned principally with silicosis. The first theory relative to the effect of dust was that its harmfulness is due to sharp, angular particles. This theory has been disproved by several investigators. Gardner's work on animals showed that carborundum dust, a harder substance than silica, would not cause the massive pulmonary fibrosis that silica produces. The size of dust particles will be discussed later, but it might be said here that only the very small particles reach the alveoli of the lung, many of them as small as bacteria and of unimportant physical hardness. Collis[2] stated that, "Generally speaking, dusts are more injurious as their chemical composition differs from that of the human body or from the elements of which the body is normally composed, whence it follows that animal dusts are less injurious than others."

With this in mind, it may readily be seen that dust from calcium, carbon, etc., common constituents of the human body, would not be expected to produce the same effect as silica or quartz, an uncommon constituent in our make-up. Research has shown that silica in its free or uncombined state is capable of producing serious pulmonary damage, whereas in its combined state, as in silicates, it is relatively innocuous. Obviously, it is important when studying a dust to know the percentage of quartz or free silica in its composition. This is accomplished by petrographic analysis. The chemical analysis of cement dust indicates the presence of about 22 per cent of silica, while petrographic analysis shows a content of only about 1 per cent of quartz. Likewise, the chemical analysis of Barre granite indicates the presence of approximately 70 per cent of silica, while by petrographic analysis only 35 per cent of quartz is found. It is not surprising that chronic conditions of the upper respiratory tract may be produced by the physical or mechanical action of dust and that possibly a chronic bronchitis may result, but only silica produces massive pulmonary fibrosis and a strong predisposition to infection with tubercle bacilli.

The theory that silica becomes soluble after remaining in the tissues has been generally accepted, and it was also agreed at the International Silicosis Conference that "there is experimental evidence that the solubility of silica in the tissues is an essential factor in the causation of silicosis." It is generally accepted that the silica particles are removed from the alveoli by the macrophages, which are sometimes called "dust cells," and are stored in the various parts of the lung. Apparently, the gradual dissolution of the silica stimulates an excessive production, with time, of fibrous tissue. Kettle[3] contrasts this slow action of silica in the lung tissue with the more rapid reaction which occurs when silica is injected into the subcutaneous tissues, in which case an inflammatory reaction is produced and in a short time necrosis takes place.

It is also well known that tubercle bacilli grow well in a medium rich in colloidal silica. Gardner[4] showed that guinea pigs inoculated with a low-virulent strain of tubercle bacilli and exposed to siliceous dust of known quantity and concentration developed clinical tuberculosis with a dissemination of the infection, whereas the controls inoculated with the same strain and dosage of bacilli failed to develop the disease to such an extent. Obviously, the effect of silica in the tissues aids in the growth and proliferation of tubercle bacilli.

Apparently, there is not the same effect in the action of other bacteria in the pulmonary tissues that is found in the case of tubercle bacilli. Likewise it has not been shown that the growth of tubercle bacilli is augmented by the presence of other types of dust. An excessive amount of other respiratory diseases can be accounted for by the lowered local resistance caused by the presence of dust and the excess of bacteria carried into the lungs by the dust itself.

CONDITION OF WORKER AT BEGINNING OF EXPOSURE

Reference has been made to the manner in which a tuberculous infection is augmented by the presence of silica. It follows that a worker having a tuberculous infection, either latent or active, will suffer more from the effects of dust than a person who is not so infected. It is highly necessary for workers to be examined thoroughly before being permitted to engage in a dusty trade. Experience with miners in South Africa has shown that a worker having a latent tuberculosis or one in whom such infection was not demonstrable, or if he was of the so-called "phthinoid" type, he developed

[2] E. L. Collis and Major Greenwood, "Health and the Industrial Worker."

[3] E. H. Kettle, "Experimental Silicosis," *Jl. Ind. Hygiene*, vol. 8 (1926), pp. 491–495.

[4] L. U. Gardner, *American Review of Tuberculosis*, December, 1929.

silicosis more rapidly and a tuberculous complication earlier than did the normal worker.

LENGTH OF EXPOSURE, CONCENTRATION, AND SIZE OF PARTICLES

The length of exposure to dust is evidently a great factor in the production of disability. It has been found that the occurrence of silicosis is in direct relation

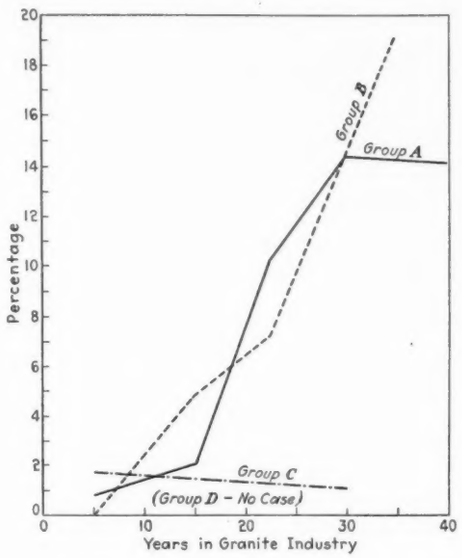


FIG. 1 PREVALENCE OF TUBERCULOSIS (ACTIVE CASES) BY LENGTH OF SERVICE AND DUST-COUNT GROUPS
(Percentage of workers diagnosed on physical examination as having tuberculosis.)

to length of service and concentration of dust. This is illustrated in Fig. 1.

EFFECTS PRODUCED

In order to determine the effects produced by dust inhalation, a number of studies were made. These observations included a study of the sickness of workers with especial reference to respiratory diseases, physical examinations supplemented by X-ray and laboratory tests, and a study of the mortality records.

Morbidity. Prior to the discussion of morbidity rates, a brief reference will be made to the extent of dustiness to which groups of workers have been exposed. The principal information presented in the morbidity studies was taken from observations made on a group of granite workers exposed to a known concentration of dust. These workers were classed in four general groups according to intensity of exposure per cubic foot of atmosphere, as follows: Groups A and B, 30 to 60 million particles per cubic foot; Group C, 20 to 30 million particles per cubic foot; Group D, less than 20 million particles per cubic foot (Fig. 1).

The frequency of disability lasting longer than one week, exclusive of that from accidents and from respiratory diseases in specified industries, is shown in Fig. 2. The lower portion of the graph shows the incidence of respiratory diseases; it may be seen that these rates are not in the same ratio as the total amount of sickness.

COURSE OF SILICOSIS AMONG WORKERS NO LONGER EXPOSED TO SILICA DUST

In the study of silicosis, one of the most important questions which has arisen is the health history of those individuals who have worked in the granite industry for a number of years and then left, to find occupations in other trades where there was no further dust exposure. It was possible during the course of the study at Barre to observe 24 such cases.

The latency of silicosis has been referred to by other investigators. The South African workers found that "a steady fall over a period of years in dust concentration is not associated: with a corresponding fall in the silicosis incidence."[5] Dr. Watkins-Pitchford also records cases of miners who had been exposed to dust for a long period of time, apparently sufficient to develop silicosis, but who went into the war apparently not silicotic. He asserted that such cases were liable to

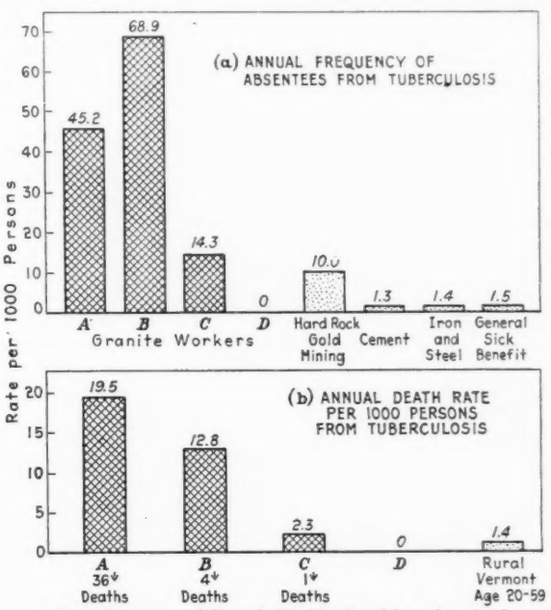


FIG. 2 (*a*) ANNUAL FREQUENCY OF ABSENCE FROM TUBERCULOSIS (EIGHT DAYS AND MORE). (*b*) ANNUAL DEATH RATE PER 1000 PERSONS FROM TUBERCULOSIS

develop tuberculosis. Dr. Pancoast presents a case of advanced pneumonoconiosis in a quartz miner who had been exposed to dust for eight years. He had been out of the mining industry for 10 years, yet the X-ray showed extensive pneumonoconiosis with irregularities of diaphragm, and by fluoroscope he found the diaphragm restricted on each side. There was, perhaps, a tuberculous infection intervening at the time.[6]

[5] South African Institute Medical Research, Annual Report for year ending Dec. 31, 1925.

[6] Henry K. Pancoast, "Roentgenological Studies and Other Fibrosing Conditions of the Lungs," *Analysis of Clinical Medicine*, July, 1923.

Britton[7] reports two cases of workers who had been exposed to dust between seven and eight years. They changed occupations and had been away from siliceous dust for eight and nine years. They developed pulmonary symptoms and were found to be suffering from silicosis and tuberculosis. Tattersall[8] also observed cases of latent silicosis in his studies: "Some of the men (rock drillers), moreover, had changed their occupation for various reasons quite apart from health, but in due course the inevitable dyspnoea came on. One man, for instance, worked eight years regularly with rock drills from 1906 to 1914, then joined the Army, was passed as A-1; but in spite of his open-air life, dyspnoea came on in 1918, and from then until his death six years later his illness was a typical case of silicosis."

MORTALITY

The influence of dust on mortality from tuberculosis is clearly indicated in the following table. New methods

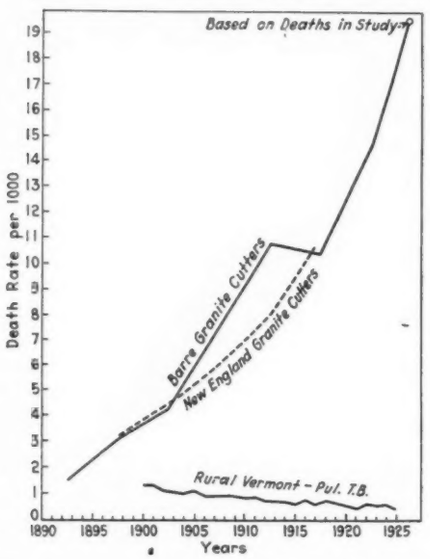


FIG. 3 TREND OF MORTALITY FROM TUBERCULOSIS AMONG GRANITE CUTTERS COMPARED WITH THAT IN RURAL VERMONT

of manufacturing stone which created excessive dust by the use of pneumatic tools, were introduced in the granite industry about the beginning of the present century, and the tuberculosis rate has increased rapidly with their use. The rate has risen in direct proportion to the length of time during which they have been employed, as follows:

1.5 per 1000	1890–1894
10.8 per 1000	1910–1914
19.5 per 1000	1924–1926*

* During period of our observations.

A consideration of the mortality statistics of Barre, Vermont, shows that there has been an excessive death rate from pneumonia and other respiratory diseases (tuberculosis excluded) during this period.

Fig. 3 shows the age curve of mortality of workers using hand pneumatic tools as well as that of males in rural Vermont. The rate of the latter may have been influenced by the fact that many disabled cutters move to

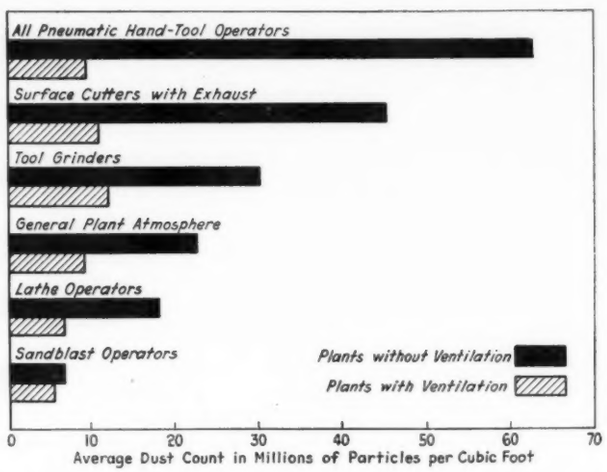


FIG. 4 SHOWING THE DIFFERENCE IN ATMOSPHERIC DUST CONDITIONS BETWEEN A GRANITE PLANT EQUIPPED WITH EFFICIENT LOCAL EXHAUST VENTILATION AND PLANTS NOT SO EQUIPPED

rural districts. However, the contrast between the two rates is great.

SUMMARY

Morbidity and mortality records indicate that workers exposed to dust have excessive rates of respiratory diseases.

Inorganic dusts produce more pulmonary disability than organic dusts.

Silica (SiO_2) of the crystalline variety (quartz) is the element in dust which produces the greatest pulmonary damage, and it is present in varying extents in most industrial dusts.

Silicosis is insidious in its onset and progress, and presents but few symptoms or physical signs in its early stages.

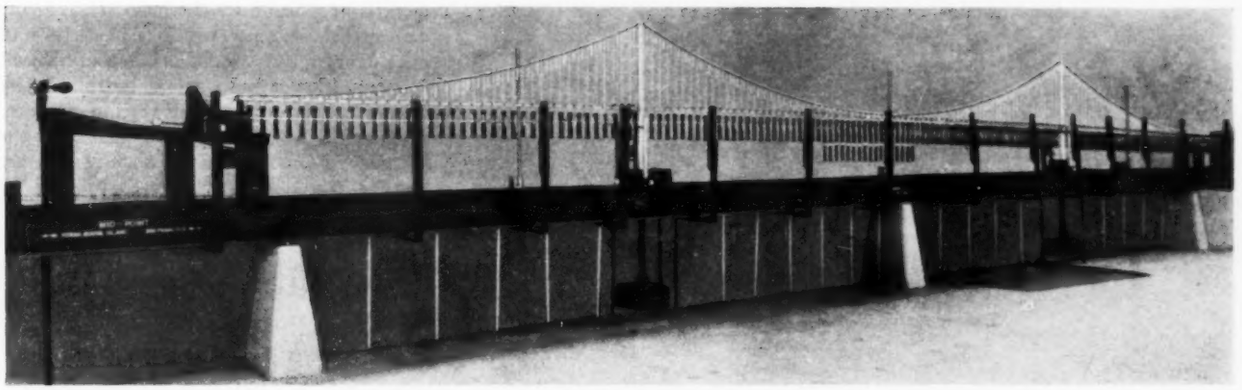
Silicosis is almost invariably complicated by tuberculosis after a number of years of exposure, which time depends upon the concentration of the dust and the percentage of free silica which it contains. Latent tuberculosis is usually activated after shorter exposure to siliceous dust, and has more characteristics of this disease in persons not in dusty trades.

Masks frequently give a false sense of protection. Removal of dust at its source is preferable (Fig. 4).

There has been a great reduction in the death rate from tuberculosis among the general population during recent years, while among workers in dusty trades there has been a great increase during the same time in the death rate from this cause.

[7] James A. Britton, M.D., "Silicosis, a Modern Factory Hazard," *Jl. Ind. Hygiene*, September, 1924.

[8] Norman Tattersall, M.D., "The Occurrence and Clinical Manifestations of Silicosis Among Hard Ground Workers in Coal Mines," *Jl. Ind. Hygiene*, November, 1926.

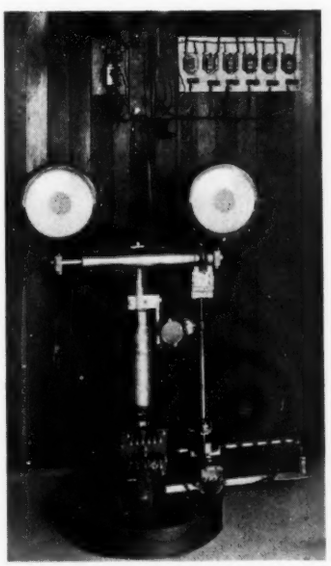


MODEL OF SAN FRANCISCO–OAKLAND BAY BRIDGE

The Place of the University IN INDUSTRIAL RESEARCH

By BALDWIN M. WOODS[1]

THE first and most obvious demand upon the university is to serve as the training ground for future research workers to man the industrial laboratories of the country. Unfortunately colleges of engineering were, until recently, so completely absorbed in the problems of training men for the more common demands of industry that little time and energy was left for the special preparation of research workers. Some one has said that there are probably not more than 900 instructors and students engaged in engineering research in the colleges, while one, perhaps the largest, of the industrial-research institutions employs 4000. Since there is a relatively high mortality or obsolescence, if one wishes to call it that, among men who choose to undertake research, it seems that the universities will have a large task on their hands if they furnish an adequate number of workers for the future. One of the results of the depression in university life has been the return for graduate study of a larger percentage of the better men than was the case in the period of industrial prosperity. This trend will, in itself, provide a larger number of trained men for this special field. In addition, industry is calling upon the departments of physics and chemistry for industrial researchers, especially since the knowledge of the newer developments in these fields is often of the greatest importance. Some industries have charged that our engineering colleges have paid so little attention to the newer developments in physics and chemistry that they have found it desirable to go abroad for their research workers. In my opinion this condition is likely to correct itself rather rapidly in the year to come. The University of California, for example, has just authorized the granting of the engineer's degree for two years of graduate work, a considerable portion of which will in most cases be devoted to modern developments in physics, mathematics, chemistry, etc. In spite of these favorable trends, however, it is exceedingly important that the output of university men technically trained for research shall be kept high.



AUTOMOBILE-HEADLIGHT TESTING STAND

In the second place, the university, through its colleges of engineering, should engage in research of fundamental character. The extent to which this will become industrial research must depend in each case upon local conditions and the development of industrial research in the industry concerned. For example, in electrical engineering, industrial research by great corporations has included so much of fundamental or pure-science character that the university does not need to undertake applied research to any great extent in order to maintain a proper overlapping with industrial research. In some other fields, however, it will be necessary for the university to join hands with industry by doing not merely fundamental research but also applied research of an industrial character, in order to maintain the proper contact. In the field of mass concrete at the present time, researches at the University of California are focused upon a large industrial problem, that of the Hoover Dam. To be sure, much of the work is leading to knowledge of general usefulness.

An illustration from the field of gas may be of value. A year and a half

[1] Chairman, Department of Mechanical Engineering, University of California, Berkeley, Calif. Mem. A.S.M.E.

ENGINEERING MATERIALS LABORATORY, UNIVERSITY OF CALIFORNIA

ago the University of California undertook the study of the stability of flames from atmospheric-type burners. An examination of the literature showed that many tests of burner efficiency had been made and that maximum efficiency in operation had been determined for many cases. It was impossible, however, to find anywhere a fundamental analysis of the phenomena of combustion including the determination of the velocity of flame propagation for different mixture ratios. If it were possible, for example, to know the effect on flame propagation of changing the mixture of gases used in the burners and the laws governing these changes, then the subject of burner design might be reduced to a science based upon these laws. This process has, of course, been developed by scientists and engineers in many other fields. Apparatus for the purpose of combustion investigation is now complete, and the credit for its assembly and testing is due to last year's Pacific Coast Gas Association Fellow, Mr. Hugh H. Hyde. It is hoped that during the coming year results from this study will be forthcoming and that they may later be applied in industrial design. Fundamental studies of this character naturally require time, and there is a lag between the obtaining of positive results and their application in industry. It is in the nature of university investigation to proceed more slowly than industrial-research organizations. On this account many problems of industrial research are not suitable for university study. Where quick answers are necessary, and where the problem is largely one of testing instead of fundamental analysis, research in industrial laboratories operated by the industry itself seems to be the solution. It is our belief, however, that for the university and for industry to obtain the best results, the policy of each should be directed to a moderate overlapping of fields. The university should start from pure research and go out to meet industry in applied research. Industry should give primary attention to its immediate problems, and secondary consideration to those of fundamental character from which results are more distant. Dr. Robert A. Millikan has remarked: "The only difference between pure and applied science is in the immediateness of the end. Pure science works for practical ends just as much as applied science does. But the ends are bound to be more remote."

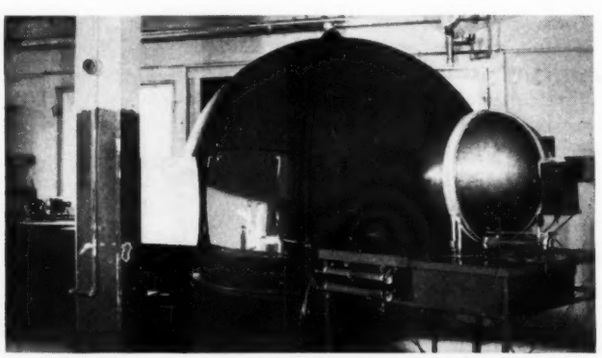
From what has been said, it will be recognized that the university, in its engineering research, has not thought of competing with regular engineering testing firms. Testing for the control of products is also outside its field. Common experience, in the opinion of a number of authorities, places such testing under the control of industry itself. At the present time, testing for the purposes of rating is undertaken in general only when the university must serve as official judge or arbiter. For example, the state of California maintains its laboratory for the testing of automobile headlights and signaling devices at the University of California. All such devices are tested in this laboratory before approval by the state. It may be of interest, however, to note here that a number of very interesting problems of fundamental character have arisen from what might have been a routine testing laboratory.

RESEARCH IN ITS RELATION TO THE PROBLEM OF EMPLOYMENT

One should not dismiss the subject of research and its implications in these days without reference to the problems of personnel and employment. It is likely that the recent past has been an era in which increased efficiency of industry has been attained in large degree by the elimination of labor. It is equally likely that there is a saturation point to this process and that society must soon devise means of providing employment for all its workers. Tremendous political and social pressure will develop for such accomplishment. Reformers and statesmen will insist upon it. This means, as I see it, that the engineer and business man in seeking future progress must solve the problem of maintaining employment in industry as a whole just as they have solved problems of production and marketing. In a recent discussion of the value of research to industry, R. P. Shorts[2] says:

> Sometimes I think that too many ideas are developed to decrease human labor and too few to increase it. Production costs are cut down either by reducing the expense of labor or the expense of material, and as a rule labor gets the worst of it. Often that which is achievement for the inventor is ruin for the worker. The up-to-date test of the value of a new machine is—how many men will it cut off the payroll? If it will pay for itself in two years, or some say even in three, it is a good buy. There is a tragedy about it all that brings much unhappiness and bitterness into the world, and I believe the time will some day come when the resourceful man of research, who through long and careful study succeeds in developing a new product which will *increase* and not *diminish* the demands for human labor, will be hailed as a public benefactor of the highest type.

[2] University of Michigan, Department of Engineering Research, Circular Series No. 4.



ULBRICHT SPHERES (84-IN. AND 24-IN.) USED IN TESTING AUTOMOBILE HEADLIGHTS AT THE UNIVERSITY OF CALIFORNIA

A New High-Speed
ENGINE INDICATOR

By E. S. TAYLOR[1] and C. S. DRAPER[2]

THE difficulty of making an instantaneous indicator which will give quantitative results at high speed has led to the development of a number of indicators of the averaging or point-by-point type. For various reasons none of these indicators has been completely satisfactory. In response to the need for a better instrument, a new indicator of this type has been developed by cooperation between the Aeronautical Engine Laboratory and the Electrical Engineering Department at the Massachusetts Institute of Technology.

The sampling-valve type of indicator is subject to the difficulty and uncertainty of opening and closing a small valve in an extremely short time, together with the necessity of using a tube of considerable length between the valve and the cylinder. These factors of uncertainty cause doubts as to the advantage of this type of indicator over the simpler instantaneous type, since neither indicator will give an accurate quantitative measurement.

The balanced-valve indicator gives a closer approximation, but is also of doubtful accuracy owing to the difference in area exposed to pressure on the two sides of the valve. This difference is indeterminate since it depends on the condition of the valve seats. There is also the disadvantage of having to disassemble the valve at frequent intervals for cleaning and regrinding. The recording mechanism for this indicator is, however, reasonably simple and satisfactory.

It is generally conceded that the balanced-pressure diaphragm type of indicator, the best-known example of which has been developed by the Bureau of Standards, is the most accurate instrument available for measuring the rapidly varying pressures in engine cylinders. Unfortunately, the method of taking indicator cards with the Bureau of Standards mechanism is very laborious.

The indicator described in this paper is an attempt to combine the convenience of the recording mechanism of the Farnboro balanced-pressure valve with the accuracy and freedom from trouble of the Bureau of Standards balanced-pressure diaphragm. In fact, it is quite possible to use these standard units without modification together with the special electrical circuit to be described, but for reasons of economy and convenience it was found desirable to make certain changes.

It was foreseen, and confirmed experimentally, that breaking the primary current of a spark coil directly by means of the diaphragm would lead to serious difficulties and that some form of relay would be necessary. The gas-filled thyratron tube has the characteristics desired in a relay for this purpose. With the aid of the Department of Electrical Engineering at M.I.T. a circuit was designed around this tube which will cause a discharge at the secondary terminals of a spark coil when the balanced diaphragm makes or breaks a very small current in the grid circuit of the tube.

The diagrams of the two electrical circuits, one for the "make" and one for the "break" of the diaphragm contact, are shown in Fig. 1. By means of a three-pole double-throw switch it is possible to change from one circuit to the other. A sample indicator card is shown in Fig. 2. The rising pressure is recorded by the "make" circuit, and the falling pressure by the "break" circuit. Recording the rising and falling pressures separately insures that there will be no gap at the top of the card, and that the actual maximum pressure will be recorded. Fig. 3 shows the card plotted on the pressure-volume scale. Note the close agreement between the imep as measured by the usual method and by the indicator.

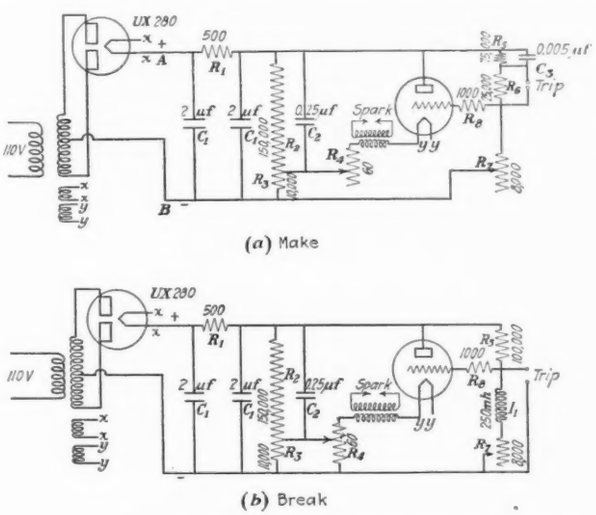


FIG. 1 MAKE AND BREAK CIRCUITS OF DIAPHRAGM CONTACT

The operation of the electrical circuits is described in the Appendix.

Drawings of the balanced-pressure diaphragm element are shown in Fig. 4. It will be noted that the unit is small enough to be placed in any ordinary 18-mm spark-plug hole. This element is a slight modification of the National Advisory Committee for Aeronautics element, with which it is interchangeable. The diaphragm used has an effective diameter of $^3/_8$ in. and is 0.003 in. thick. In spite of the fact that no special cooling is used, no valve between the diaphragm and cylinder is necessary, and diaphragm failure is very infrequent. N.A.C.A. Technical Note No. 359 gives the reasons for modifying the form of the original Bureau of Standards diaphragm indicator. The reason for deviating from the N.A.C.A. design is merely for ease of manufacture.

Fig. 5 shows the recording element. It will be noted that the sparking point is connected directly to the piston, eliminating the usual multiplying mechanism. The piston works

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[2] Research Associate, Department of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

in the cylinder with a lapped fit. The size of the record has been made generous in order that the errors of measurement will be reduced to a minimum. The record drum is provided with a brake to eliminate possible backlash in the driving shaft and clutch. The clutch is made so that it always engages in the same position, making it possible to keep the joint in

maximum pressure is exceeded sparks will cease to jump from the sparking point. The triple-pole switch is thrown and the pressure gradually reduced to atmospheric. When the card has been taken, the spark is recorded on the diagram by disconnecting the wire from the diaphragm unit and connecting one which runs near an ignition cable. By running the

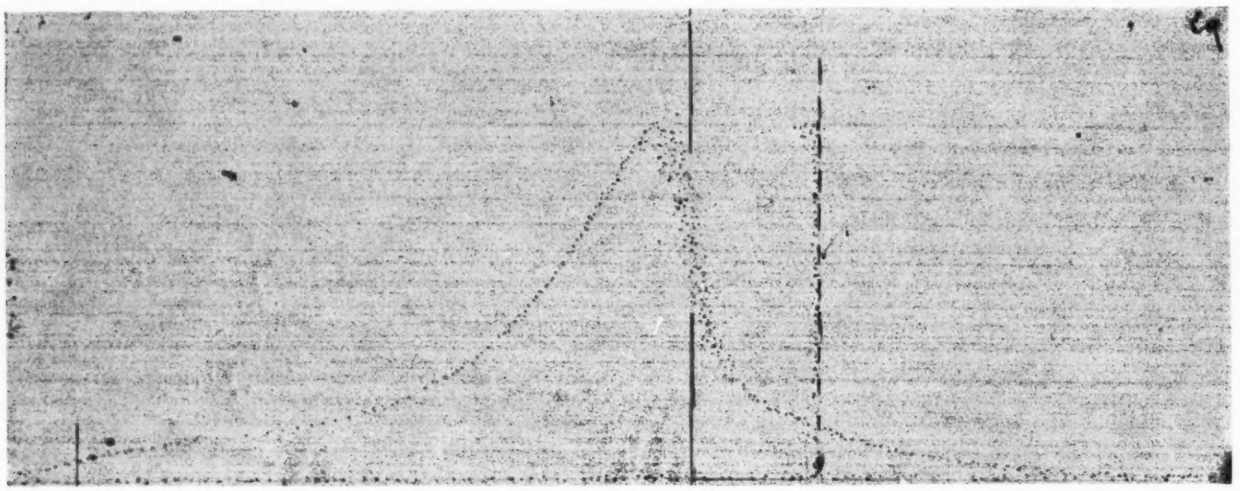

FIG. 2 SAMPLE INDICATOR CARD

the record away from the part of the card of particular interest. The recording element is mounted with provision for vertical adjustment on a portable cabinet which also carries the electrical unit as shown in Fig. 6. This makes a very convenient unit which may be connected to any of the engines in the laboratory in a few minutes.

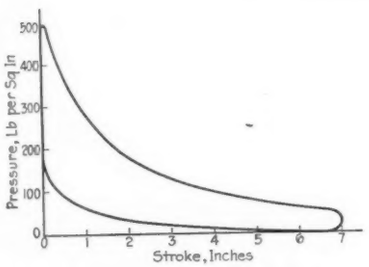

FIG. 3 CARD OF FIG. 2 PLOTTED ON THE PRESSURE-VOLUME SCALE

[N.A.C.A. engine, 5:1 compression. Imep = 131 lb per sq in.; bmep = 108 lb per sq in.; fmep = 20.5 lb per sq in. (motoring test).]

The operation of the indicator described is like that of the Farnboro type, except that the three-pole double-throw switch is operated when the maximum cylinder pressure has been exceeded. There is no necessity for protecting the pressure element from cylinder pressure when not actually in use, and no special cooling is required. The diaphragm element is screwed into a spark-plug hole and connected to the pressure line by a $^3/_{16}$-in. copper tube and wired to the electrical circuit. The wire must be kept away from the ignition cables, or the pick-up will be sufficient to cause the spark to mark the record. This is undesirable while taking the card since it interferes with the proper operation of the circuit. In some cases it might be necessary to use a shielded lead from the diaphragm unit. The recording unit is placed in position and the drum is directly connected to the engine crankshaft. A piece of carbon paper is placed on the drum, carbon side in, and secured by rubber bands. The sparking point is swung into position and the clutch is thrown in, causing the drum to revolve. The electrical circuit is then switched on. The balancing pressure is slowly increased by opening the valve from the nitrogen cylinder. When the

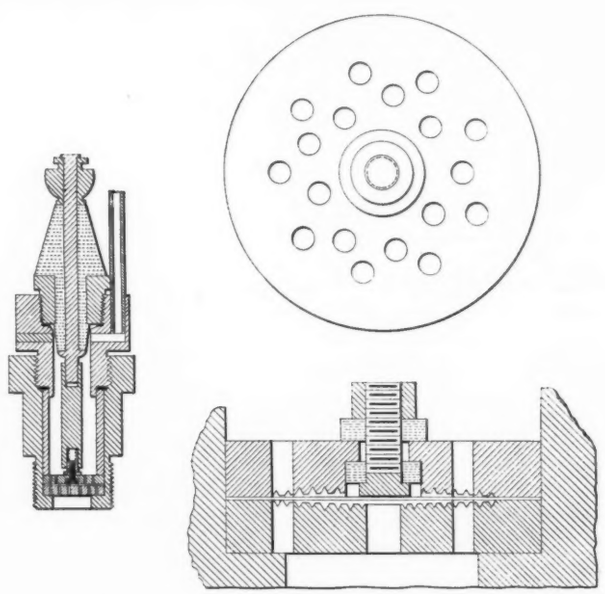

FIG. 4 BALANCED-PRESSURE DIAPHRAGM UNIT

(Enlarged detail of diaphragm and seats at right.)

pressure up and down, the spark is recorded as a vertical line on the record. The card is now complete and ready for inspection. By recording the ignition spark directly on the drum and then through the thyratron circuit, it has been shown that the lag in the electrical circuit is so small that it cannot be detected by this method. It may therefore be neglected. The correct phase relation of the card is obtained from the ignition spark, the timing of which should be measured by a neon-light spark protractor such as is used on the C.F.R. engine. On very hot days some trouble has been experienced

owing to overheating of the thyratron. This, however, can be controlled by means of a small fan.

APPENDIX[3]

The problem is to control a large current impulse through the primary of the spark coil by means of a very small current in the contacts on the pressure diaphragm. This may be accomplished by some form of electrical relay, and the most satisfactory type for this particular problem seemed to be the thyratron.

The thyratron is a three-element gas-filled tube with two valuable and special characteristics. First, the grid only prevents starting a flow of current through the tube. It has no control over the current once it has been established. The only way that the tube can be extinguished and the grid resume control is for the current in the tube to be brought to zero. Secondly, the thyratron is capable of handling large currents with a very small voltage drop in the tube.

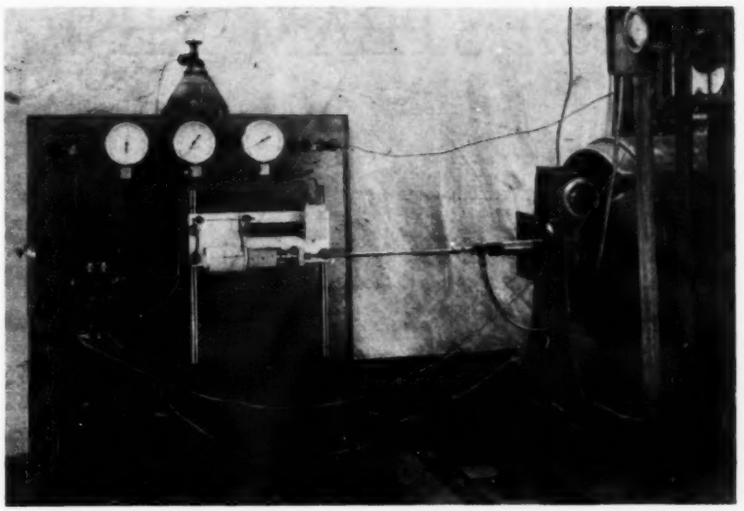

FIG. 6 RECORDING ELEMENT ON CABINET CARRYING ELECTRICAL CIRCUIT

Fig. 1(*a*) is the circuit diagram to operate when the contacts are made. A conventional full-wave rectifying system gives 400 volts dc at 100 milliamperes at the points A and B. The condensers C_1 and the 500-ohm resistor form a filter system to reduce the alternating-current ripple from the rectified supply.

With the contacts open and the thyratron in a non-conducting state, condenser C_2 [Fig. 1(*b*)] charges to nearly 400 volts. This voltage is impressed around the circuit consisting of the condenser C_2, the thyratron, the spark-coil primary, and the 60-ohm rheostat. There is a current flowing from plus to minus through the 150,000-ohm resistor R_2 and the 10,000-ohm resistor R_3. The resulting voltage drop in R_3 raises the potential of the filament of the thyratron to about plus 25 volts with respect to the negative lead.

In the trip circuit there is a current flowing through the 75,000-ohm resistor R_5, the 25,000-ohm resistor R_6, and the 8000-ohm resistor R_7. With R_7 adjusted to about 5000 ohms the voltage drop across it will be 19 volts. This means that the grid will be (25 — 19 =) 6 volts negative with respect to the filament. With this much negative bias the thyratron will remain non-conducting. If the trip contacts are closed R_6 is short-circuited. Since the potential across the condenser C_3 cannot be changed instantly, this means that the potential of the grid is raised by the drop formerly existing across R_6. This makes the grid positive with respect to the filament, and the thyratron becomes conducting. It should be noticed that even though the trip contacts remain closed, when C_3 becomes charged the grid is again negative with respect to the filament. This means that there will be just one spark for each time the contacts are closed, and that they must be opened and closed before the thyratron will be tripped again.

The condenser C_2 then discharges around the circuit including the primary of the spark coil, and a high potential is induced in the secondary of the coil. The total time elapsed between the closing of the contacts and the spark in the secondary of the spark coil is not more than three or four microseconds.

The discharge of C_2 is an oscillatory discharge due to the inductance of the spark coil, and hence the current in the thyratron actually reaches zero, allowing the grid to regain control. With the condenser C_2 discharged, the filament of the thyratron is nearly 400 volts plus; this places a large negative bias on the grid and materially aids in extinguishing the thyratron. Condenser C_2 now charges through the resistor R_3 and the circuit is ready to be tripped again.

Fig. 1(*b*) shows the circuit as arranged for firing when the contacts are broken. With the contacts open the grid will be negative with respect to the cathode as previously explained. If the contacts are closed the choke coil and the resistor R_7 are short-circuited, increasing the negative bias on the grid. If the contacts are then suddenly opened a voltage appears across the circuit composed of the choke coil and R_7, raising the grid to a plus potential with respect to the filament and allowing the thyratron to conduct. As soon as this voltage is able to establish a current through the choke coil, the grid again becomes negative with respect to the filament.

The change from the circuit in (*a*), Fig. 1, to that in (*b*) is accomplished by means of a three-pole double-throw switch.

[3] By H. E. Edgerton and K. J. Germeshausen, Massachusetts Institute of Technology.

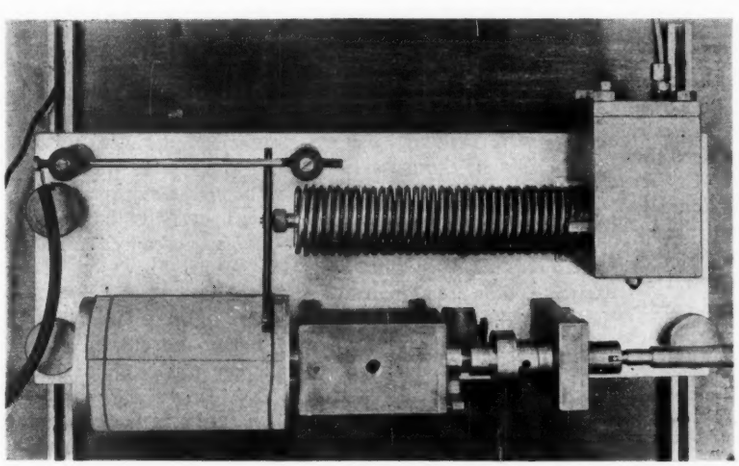

FIG. 5 RECORDING ELEMENT

Recent STEAM RESEARCH *in Europe*

By JOSEPH H. KEENAN[1]

CZECHOSLOVAKIA

FOUR years ago Dr. Havliček presented to The American Society of Mechanical Engineers a résumé of his first experiments at the Masaryk Academy of Work on the enthalpy of superheated steam. He expressed himself at that time as dissatisfied with the precision obtainable from his experimental equipment, and announced his intention to build new apparatus in preparation for a more extensive experimental program. This year we have received the results of three years' work with the new apparatus. It includes 757 measurements of the enthalpy of compressed water and superheated steam extending from atmospheric pressure to 5600 lb per sq in., and from 70 F to 1030 F.

Two methods of measurement, referred to as the condensing method and the throttling method, were used. The condensing method involves condensing a known rate of steam flow, using a measured cooling-water stream over a range of temperatures within which the enthalpy of the cooling water is accurately known. In order to carry out the condensing at low pressure the steam is throttled from the condition at which its enthalpy is to be determined down to atmospheric pressure before it enters the condenser.

The throttling method involves only throttling to atmospheric pressure. The enthalpy of the steam approaching the throttle is determined from its enthalpy after the throttle, which is in turn determined from previously executed condensing measurements.

The results of experiments by both these methods are shown as circled points in Figs. 1, 2, and 4. The superheat region (Fig. 1) has been covered by a most comprehensive series of measurements. This is, perhaps, the most important part of Dr. Havliček's work, but since it covers more familiar territory it requires less comment than do those measurements in other regions. Comparisons between Havliček's superheat data and other recent information will be subsequently discussed.

Havliček's measured enthalpy values in the compressed-liquid region are shown in Fig. 2 compared with the properties of compressed liquid water which I deduced two years ago from the calorimetric measurements by Osborne and from the specific-volume measurements by Keyes and Smith.[2] The difference between enthalpy and temperature ($h - t$) is chosen as ordinate in order to reduce the range of values. The agreement in the general shape of the constant-temperature curves is good, but there are unfortunately large differences between the enthalpy values themselves at temperatures above 100 C. At 250 C, for instance, Havliček's value for saturated liquid is lower than Osborne's measured value by about 1 kcal per kg or 0 4 per cent.

The region surrounding the critical point has attracted several experimenters since Professor Callendar reported conditions of unstable equilibrium with latent heats and vapor pressures for several degrees above the temperature usually recognized as the critical temperature. Havliček built a special apparatus for calorimetric measurement in this region of rapidly changing properties and derivatives. It consisted of a one-meter length of tubing of 9 mm inside diameter. A layer of heat-insulating material separated the tube from a water jacket through which a measured quantity of water flowed. The temperature rise of this water stream determined the quantity of heat flowing from the steam to the jacket. An additional heat flow along the tube to the connecting piping was determined by three different calibration methods, of which no details are given. This indirectly measured heat leak ranged from 10 to 20 per cent of the total heat flow. A

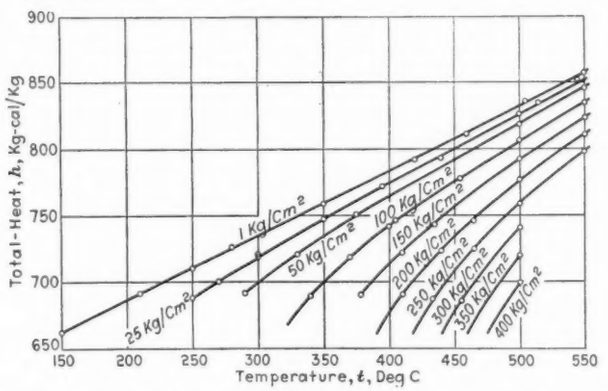

FIG. 1 HAVLICEK'S MEASUREMENTS OF THE ENTHALPY OF SUPERHEATED STEAM

platinum-resistance thermometer in a carefully constructed thermometer pocket with radiation shields and mixing passages, was placed at each end of the tube. Steam leaving the calorimetric tube was throttled, condensed, and weighed, thus giving the heat removed per pound of steam. The mean specific heat between the conditions at the two thermometer pockets was found from the heat loss per pound and the temperature change.

The steam flow was adjusted in one series of experiments to give a heat loss from the steam of 10 kcal per kg; in another series the loss was 27.5 kcal per kg. Temperature measurements were maintained at an accuracy of ±0.03 C by daily calibration of thermometers against the temperature of saturated steam at 2800 lb per sq in. The pressure drop across the calorimeter tube was about 0.01 kg per sq cm (0.14 lb per sq in.). Lines of constant specific heat, $(\partial h/\partial t)_p$, deduced from the measured mean specific heats in the neighborhood of the critical point are shown in Fig. 3. Above 374.5 C (706.1 F) no latent heat could be detected. Of course a latent heat of less than 10 kcal per kg would remain undetected by this method, but Callendar reported a latent heat of about 65 kcal per kg at 375 C.

It will be recalled that the usual chart of specific heat against temperature shows a series of constant-pressure lines converging at the higher temperatures and diverging rapidly as the temperature approaches the saturation values. The higher-

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[1] Assistant Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. Assoc-Mem. A.S.M.E.

[2] "Thermal Properties of Compressed Liquid Water," MECHANICAL ENGINEERING, vol. 53, no. 2, February, 1931, pp. 127–131.

Contributed by the Special Research Committee on Thermal Properties of Steam and presented at the Steam Tables Session of the Annual Meeting, New York, December 5 to 9, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

pressure lines sweep sharply upward at the lower temperatures, the critical-pressure line going off to infinity at the critical temperature. A similar condition exists on the liquid side of the diagram, the upward sweep occurring as the temperature rises toward the saturation temperature. For pressures higher than the critical pressure the specific heat of the liquid side sweeps upward, passes through a maximum at a temperature somewhat above the critical temperature, and then falls off with increasing temperature as do other constant-pressure curves in the vapor region.

It is this supercritical pressure range that is exhibited in Fig. 3. The line of maximum specific heats is traced out there and is found to be a smooth continuation of the saturation pressure-temperature relationship. The critical point was found, by the disappearance of latent heat, to lie somewhere between 225 and 227 kg per sq cm. This range includes the value 225.8 found by Keyes and Smith.

Starting from a condition at which the enthalpy had been measured previously by the condensing or throttling methods, the enthalpies of neighboring points at the same pressure were determined by adding on the increments in enthalpy determined by the specific-heat experiments. Such values are shown as crosses in Fig. 4, the circles being the starting points.

From the thermodynamic relationship

$$(\partial h/\partial p)_t = -A\frac{T^2}{p}\left[\partial(pv/T)/\partial T\right]_p$$

and his enthalpy measurements, Havliček calculated the variation in specific volume along constant-pressure lines. He then chose at each pressure that constant of integration which would give the best agreement between his calculated specific volumes and the measured values of Keyes and Smith. The Havliček volumes are compared with the Keyes-Smith values in Fig. 5 where the lines represent Havliček's computed values and the circles the Keyes and Smith measurements. The ordinate is the difference between the specific volume as calculated from the universal gas constant ($v_{th} = BT/Mp$) and the actual volume. In this type of diagram the difference between the circles and the lines is the actual difference between the specific volumes obtained from the two sources. Thus the apparent differences exaggerate the importance of discrepancies between values for large specific volumes and mask the significance of differences of the same size at small volumes. For instance, the difference 0.1 cu cm per gram between Keyes and Havliček at 400 C and 270 kg per sq cm is about 2.5 per cent of the specific volume. The same difference at one atmosphere would represent about $^1/_{100}$ of one per cent of the specific volume.

Considering the extraordinary precision of the Keyes-Smith measurements, it is not reasonable to expect new light on the region covered by those measurements from values derived as indirectly as those of Havliček. Nevertheless the Havliček volumes will serve to guide extrapolation of the measured volumes. Also, through their agreement with Keyes and Smith, they constitute a justification of the constant temperature characteristics of the Havliček enthalpy measurements.

GERMANY

During the past year Dr. Koch of the Munich Institute of Technology published an account of a series of experiments somewhat similar to Havliček's specific-heat measurements.[3] One of Dr. Koch's objectives was to make an independent investigation of the phenomena immediately above the con-

[3] "Das Verhalten des Wassers im kritischen Gebiet," W. Koch, *Forschung*, vol. 3, no. 4, pp. 189–192.

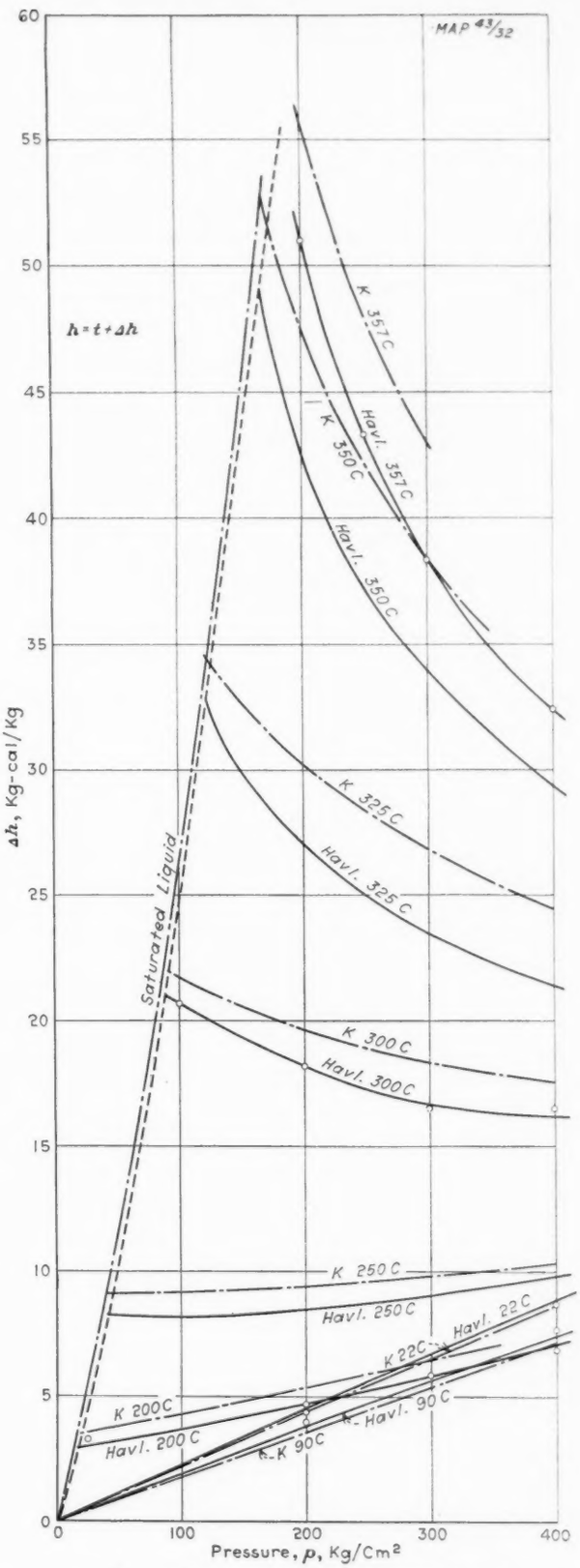


FIG. 2 ENTHALPY OF COMPRESSED LIQUID WATER

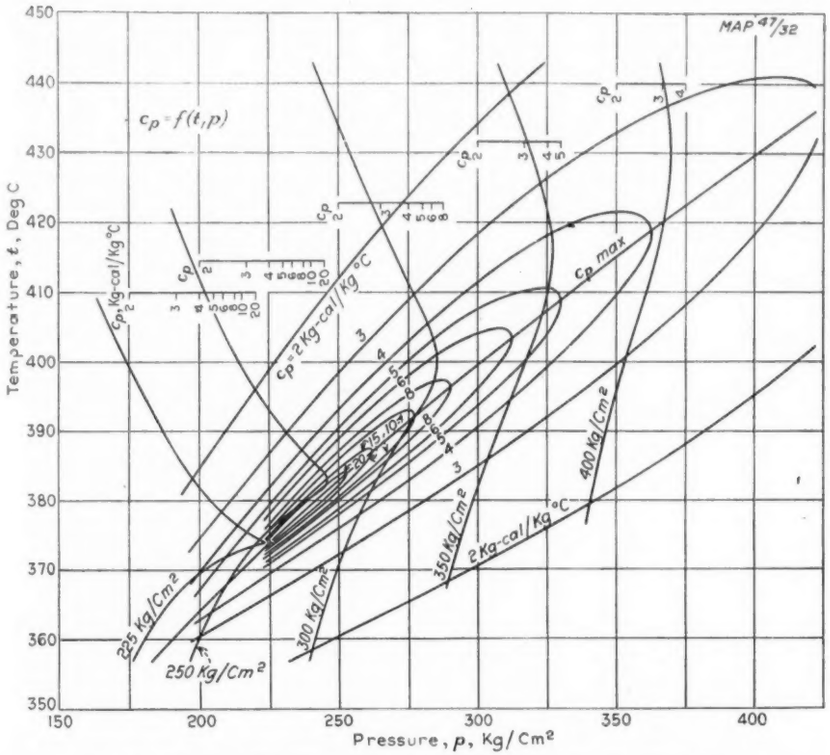


FIG. 3 HAVLICEK'S SPECIFIC-HEAT CONTOURS ABOVE THE CRITICAL POINT
(The numbers on the curves give the constant-pressure specific heat in kcal per kg. Cross-curves are also shown. The critical point according to Keyes and Smith is shown as a cross.)

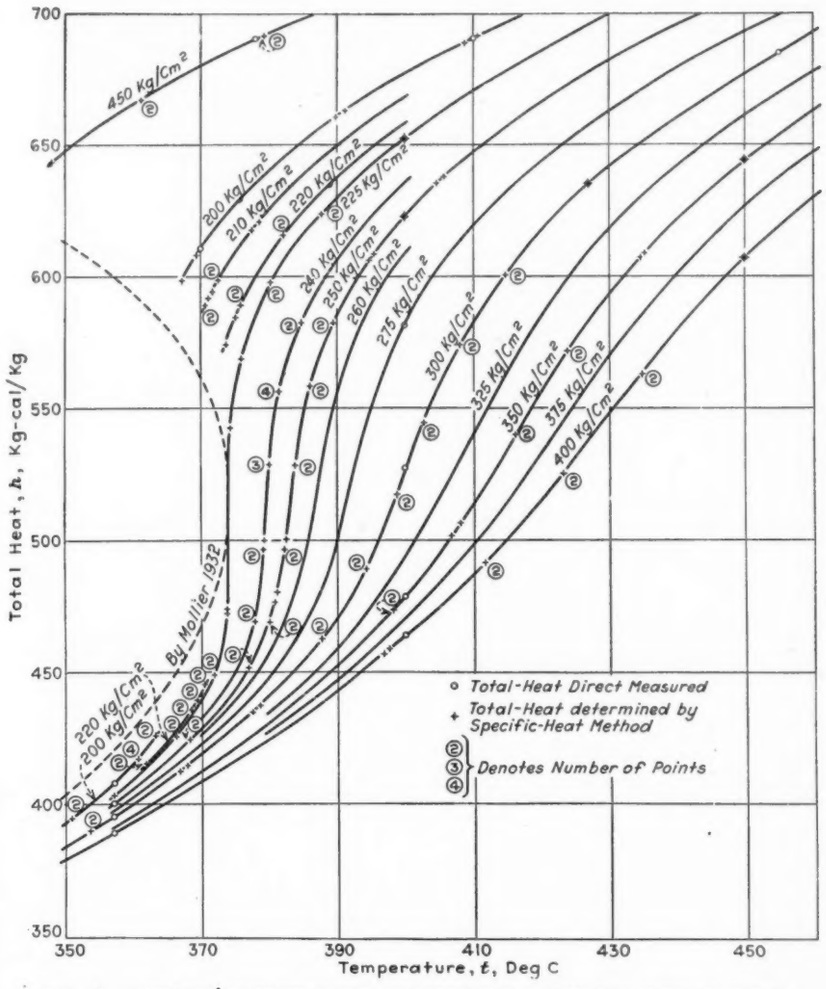


FIG. 4 HAVLICEK'S MEASUREMENTS OF ENTHALPY ABOVE THE CRITICAL POINT

ventional critical point where Professor Callendar found a metastable region with well-defined latent heats. Koch's method consisted of the measurement of the temperature rise at constant pressure caused by the introduction of a small heat flow to a stream of steam flowing at a measured rate. If he encountered a region of vaporization, there would of course be no temperature change for small additions of heat. He chose a pressure (3400 lb per sq in.) at which Callendar had found a latent heat of about 35 kcal per kg.

Professor Callendar had served ample warning that unless the steam was brought to temperature slowly, and unless it was carefully freed from air, no region of vaporization would be found. Koch deaerated his boiler feed with even more meticulous care than Callendar had exercised, and he heated his steam very slowly in the boiler and superheater; but he found no latent heat. The changes in enthalpy along this constant-pressure line as pieced together from the measured increments are shown along with Callendar's values in Fig. 6. In order to find the effect of air content on the constant-pressure curve, Koch bubbled an air stream through his feedwater, but the amount dissolved even under these extreme conditions produced no measurable effect. Rapid heating and slow heating gave results that were indistinguishable.

Koch and Havliček by continuous-flow methods and Keyes and Smith[4] by a static method have all experimented in the region immediately above the conventional critical point. None of them have found any evidence of a latent heat. Callendar's observations remain unverified.

[4] Progress Report, by L. B. Smith, MECHANICAL ENGINEERING, vol. 49, no. 2, pp. 160–161.

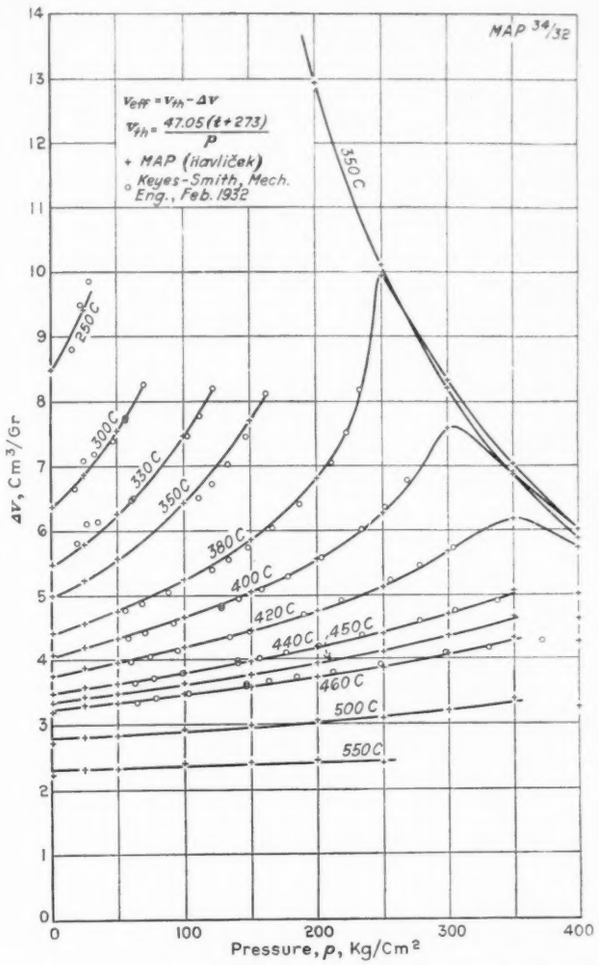


FIG. 5 COMPARISON OF HAVLICEK SPECIFIC-VOLUME INTEGRATIONS WITH KEYES-SMITH SPECIFIC-VOLUME MEASUREMENTS

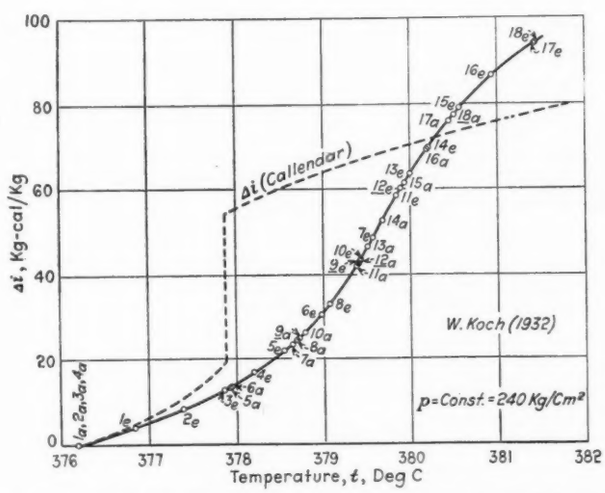


FIG. 6 KOCH'S MEASUREMENTS OF THE VARIATION IN ENTHALPY WITH TEMPERATURE AT 240 KG PER SQ CM (3413 LB PER SQ IN.) COMPARED WITH CALLENDAR'S VALUES

(Underscored numerals indicate experiments with steam generated from air-saturated water.)

The specific-heat values derived from Koch's experiments are shown in Fig. 7 compared with those of Havlíček for the same pressure. The agreement is by no means perfect. It should be borne in mind, however, that this is a comparison of slopes of experimentally determined curves in a region of very rapid change. The two investigations give positions of the point of maximum specific heat which agree within $^1/_3$ deg C. The magnitude of the old Regnault value for the specific heat of steam is indicated on the diagram for comparison with the huge values encountered in modern research.

Another recent paper by Koch[5] consists of a reformulation of the Munich specific-heat measurements in the superheat

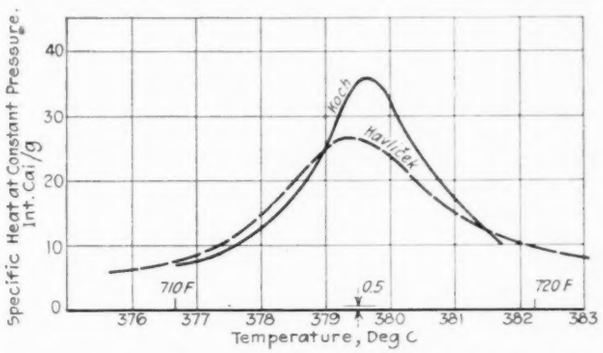


FIG. 7 KOCH AND HAVLICEK SPECIFIC HEATS AT 240 KG PER SQ CM (3413 LB PER SQ IN.)

(A value of 0.5, an approximation to the Regnault value for superheated steam, is shown for comparison.)

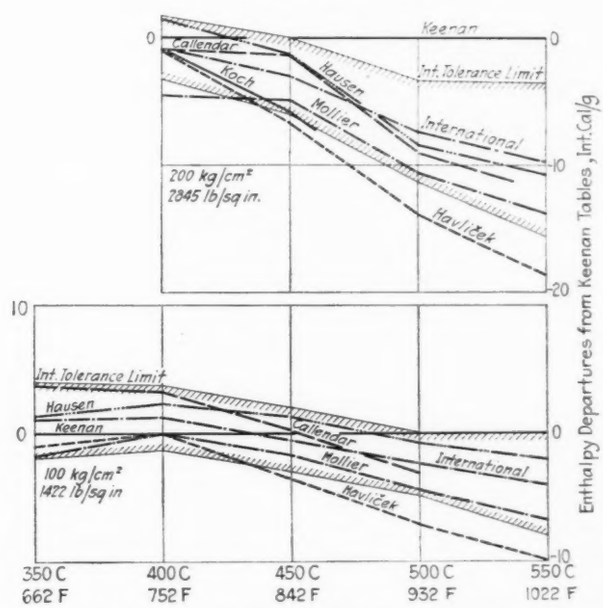


FIG. 8 COMPARISONS IN REGIONS OF HIGH PRESSURE AND HIGH TEMPERATURE

(The Keenan table is the zero line.)

region at pressures above 1700 lb per sq in. This range was included in the formulation of the same data by Hausen which appeared early in 1932 in steam-table form.[6] Koch's integrations start from saturation values interpolated from the Inter-

[5] Koch, *Zeit. f. Tech. Phys.*, 1932, no. 6, p. 266.

[6] "Tabellen und Diagramme für Wasserdampf," Knoblauch, Raisch, Hausen, and Koch. Oldenbourg, 1932.

national Skeleton Tables. As shown in the upper diagram of Fig. 8, they yield somewhat lower values of enthalpy than Hausen found, and only slightly higher than Havliček's experimental results.

COMPARISONS

There is still much uncertainty as to the properties of steam in those outlying districts beyond 1400 lb per sq in. in pressure and above 750 F in temperature. In Fig. 8 the four recent steam tables[7] which constitute individual studies of recent experimental data are compared with the experimental data of Havliček, the Koch integrations, and the International Skeleton

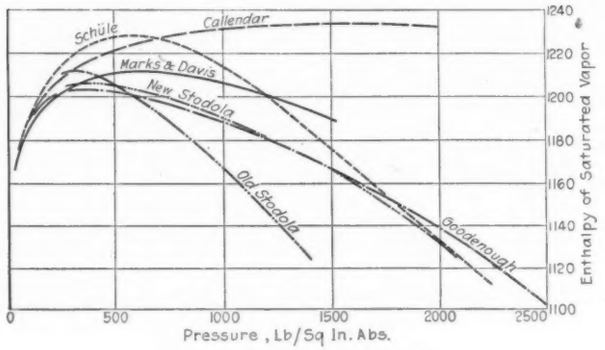


FIG. 9 STEAM TABLES OF 1922

Tables. For convenience I have used my own steam tables as the basis of comparison.

At 1400 lb per sq in. there is a moderately good agreement to 900 F, though if Havliček is correct all the tables except Mollier's are high in enthalpy. At 2800 lb per sq in. there is strong evidence that my enthalpy values above 800 F are too high. Havliček again is far below all other estimates, with the possible exception of Koch's integration. From comparisons in the liquid region it appears that Havliček is in error on the low side. It is quite likely that the truth lies higher

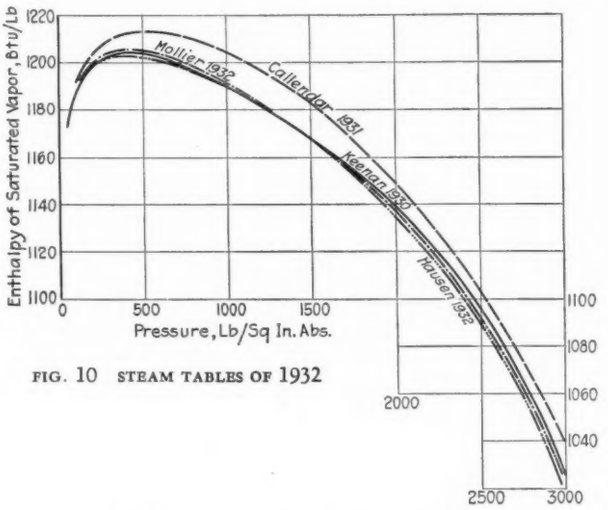


FIG. 10 STEAM TABLES OF 1932

than the Havliček values and lower than the International values.

In order not to overemphasize existing disagreements I have prepared Figs. 9 and 10 which show the saturation curves on the enthalpy-pressure plane as taken respectively from the steam tables of 1922 and those of 1932. The range of choice at 1500 lb per sq in. covered more than 100 Btu per lb in 1922. Today it is about 15, and would be less than 1 were the Callendar table excluded. It is the remaining difficulties that attract discussion; the solid accomplishments of the steam-research program are apt to be forgotten.

[7] "Revised Callendar Steam Tables (1931)," Moss. Edward Arnold, 1931.
"Neue Tabellen und Diagramme für Wasserdampf," Mollier. Julius Springer, 1932.

A New Equation Relating the Pressure and Temperature of Saturated Steam

IN DEVELOPING his equation, which he claims to be new, the author used the values given in the skeleton table of the Steam Tables Conference in London in 1929, taken from MECHANICAL ENGINEERING, February, 1930, as the standard, and for comparison gives values of the saturation pressure as calculated by equations published by several authorities.

The author attempts to derive an equation expressing in a simple way the saturation pressure of steam in terms of its temperature, giving results falling within the region of tolerance of the skeleton table, at least throughout the range of temperature contained in said table. If we had such an equation, we could find with tolerable accuracy not only the pressure p but also the differential coefficient dp/dt for any temperature. The author derives the following equation:

$$\log_e p_c/p = [a_0 + (T - T')^2/(\alpha + \beta T)](T_c/T - 1) \quad \ldots [1]$$

where p = saturation pressure corresponding to temperature t in kg per sq m
$T = t + 273$ = absolute temperature
$p_c = 225.05 \times 10^4$ kg per sq m = critical pressure
$T_c = 374 + 273 = 647$ = absolute critical temperature
a_0, α, β, and T' = constants having the following numerical values:

for t from 0 C to 200 C, $a_0 = 7.211000$, $\alpha = 86{,}000$, $\beta = 40$, $T' = 482$
for t from 200 C to 374 C, $a_0 = 7.209840$, $\alpha = 274{,}500$, $\beta = -334$, $T' = 488$

From the form of this equation it is evident that when $T = T_c$, $p = p_c$. It therefore applies to the critical point.

The values of saturation pressure calculated by Equation [1] are given in the following table:

t, deg C	0	50	100	150	200	250	300	350
p, kg per sq cm	0.00622	0.1258	1.0333	4.854	15.85	40.61	87.7	168.7

The accuracy of this equation is checked by reference to the Clapeyron equation. The author next proceeds to derive an equation for dp/dt and compares this with the previously known values. He finds that the values dp/dt calculated by his equation all lie between the maximum and minimum values which are calculated from the values of the heat contents and specific volumes, both inside the region of tolerance of the skeleton table. (Sugao Sugawara, Professor, Kyoto Imperial University, in *Journal of the Society of the Mechanical Engineers, Japan*, foreign edition, vol. 34, no. 5, March, 1931, pp. 1–4, *mt*)

The AMERICAN INCH

By SAMUEL RUSSELL[1]

THE American Standards Association at a meeting in New York on October 21, 1932, advocated for adoption in January, 1933, 25.4 as the conversion factor between the inch and the millimeter, as was forecast by Mr. H. W. Bearce, Chief Physicist of the Bureau of Standards in his article in the issue of MECHANICAL ENGINEERING for that month.

This regulation means that conversion from inches to millimeters will be made by employing this factor as a multiplier, and the conversions from millimeters to inches will be made by using it as a divisor. This is not a new proposal, for the figure originated with engineers of continental Europe who have long employed it to convert fundamental inch dimensions into those in millimeters. It was proposed for legal use in the United States in a bill (H.R. 10,736) introduced at the author's instance in the 68th Congress on April 13, 1924.

The number 25.4 is arrived at by rounding out 914.3992, the legal value in millimeters of the British imperial yard in terms of the meter of 1889, by 0.0008 to make 914.4 millimeters, which, divided by 36, gives 25.4. It is the only practicable shop ratio.

This represents a shrinkage of 2 millionths in the inch of the U. S. Bureau of Standards. It has always been the practice of the Bureau to make the inch dependent upon the metric system. However, if the Bureau felt impelled to use the meter of 1889 as a reference standard for the yard, it should have accepted and applied the correct meter value of the yard for this purpose.

THE VALUE OF THE IMPERIAL YARD

The value of the imperial yard at 914,399.2 millionths of the meter of 1889 was found in 1895 by the International Bureau of Weights and Measures in collaboration with the British Board of Trade and was confirmed by an Act of Parliament and by a Royal Order in Council at Windsor on May 19, 1898.

It is not because the U. S. Bureau of Standards has used a graduated meter as a reference or test standard for the yard, but because the Bureau has persisted in the use of a yard value of its own contrivance that is the cause of the discrepancy of 2.875 millionths between the British inch and the official inch of this country.

The correct figure for the yard in terms of millionths of the meter of 1889 was reported on page 157 of the *Proces-Verbaux du Comité International des Poids et Mesures*, Séance de 1897—and later in Tome XII, *Travaux et Mémoires, Bureau International des Poids et Mesures*, on page 24. These are the official figures. There are no others.

1 yard equals 0.9143992 meter
1 meter equals 1.0936143 yards

These figures must be accepted as a finality for transfer to terms of the red rays of cadmium:

1 meter equals 1,553,164.13 wave lengths
1 yard equals 1,420,212 wave lengths

This is the largest meter value for the yard which has been found. It will not be changed. It must be accepted as a legal finality. This means that the true equation is:

1 inch plus 0.875 millionth of an inch equals 25.4 millimeters

or

1 inch equals 25.4 millimeters minus 0.875 millionth of an inch

The Bureau of Standards is using a yard of 1,420,216.122 wave lengths in order to comply with an Act of Congress of 1866 and produce an "inch" equal to $^{100}/_{3937}$ meter. This elongates the inch by 2.875 millionths and the yard by 103.5 millionths of an inch, which is not what the Act required.

This figure produces 39,450.448 wave lengths to the inch, and Mr. Bearce in his article informs us that "gage blocks are calibrated upon this basis; line standards are graduated and calibrated on this basis. Any change from that basis will mean a change in the United States inch."

But Mr. Bearce proposes a change in what he calls the "United States inch." He proposes a yard of 1,420,213.28 wave lengths in order to produce an inch of "exactly" 25.4 millimeters. This proposal elongates the inch by $^{7}/_{8}$ of a millionth and the yard by 31.5 millionths of an inch.

The non-metric proposal is for a yard of 1,420,212 wave lengths in order to produce exactly 36 inches to the yard and bring us into exact accord with the present legal standard translated into wave lengths of the red radiation of cadmium.

The Bureau of Standards has no practical high-precision yard standard. In lieu of the yard it uses a theoretical length which has for its *terminus a quo* the zero line on a meter scale, and for its *terminus ad quem* a suppositious line between the 914th and 915th millimeter lines on this scale. The variation from the 914th millimeter line can be found and certified by this means, and that is all that can be done with it. It is not a yard standard.

This practice of the Bureau of Standards presents in rather clear terms the issue whether the yard is

914 mm plus 0.3992 mm

or is

914 mm plus 0.40183 mm

The difference between these values is 2.63 microns, or 103.5 millionths of an inch. And that is just what all the controversy is about. The first figure is law. The second figure is a fiat of the Bureau's.

As stated in Mr. Bearce's article, "Adopting a ratio betweeen units does not, however, fix their values until one of the two has been independently defined."

If in the quasi-equation:

1 inch equals 25.4 millimeters

the inch be taken as the definitive member, we obtain a millimeter which is short by 0.034 millionth of an inch. If on the other hand we take 25.4 millimeters as the definitive member, we obtain an inch which is long by 0.875 millionth of an inch. In view of the fact that the millionth of an inch has become the dominant unit for spectroscopic measurement in the expanding science of optics, the introduction of an error of $^{7}/_{8}$ of a millionth into the basic inch is a procedure that should be interdicted.

[1] Washington, D. C.

But Mr. Bearce proposes to add 0.036 wave length to the inch in order to make the inch exactly equal to 25.4 millimeters, and in his argument he says:

"It will be evident that for industrial purposes the difference of 0.036 wave length of light to the inch is not very serious. On the other hand, a difference of this magnitude is not negligible for spectroscopic work and other optical and interference measurements." By this disclosure Mr. Bearce destroys his argument for an arbitrary elongation of the inch by 0.036 wave length, which procedure would destroy its utility as a precision unit of the highest order.

For years the Bureau of Standards has contended that the discrepancy between the British and the Bureau's values for the yard in terms of millionths of the meter of 1889 was so small that it could be ignored, and at the same time was so large that it could not be corrected. But Mr. Bearce now says that this discrepancy is so large that it must be corrected, but that it cannot be corrected except to the extent of the Bureau's receding from 914.40183 to 914.4, which reduces the discrepancy from 103.5 to 31.5 millionths of an inch. He thinks that Great Britain will agree to accept this deviation from the British standard as a compromise.

The legal meter value of the yard, 914,399.2 millionths of a meter, is of secondary importance in England, because the British take the inch directly from the imperial yard. But this legal value is of primary importance in the U. S. Bureau of Standards, where it must be used in lieu of a yard standard. The British have neither cause nor occasion to change this value to please Mr. Bearce. Mr. Bearce, on the other hand, has every cause to accept and apply it.

THE AMERICAN YARD LEGALLY AND THEORETICALLY IDENTICAL WITH THE ENGLISH YARD

The cardinal fact is that the line measures of the mechanical and engineering trades of the United States have been derived directly from the imperial yard. The American yard is legally and theoretically identical with the English yard. We do not need new legislation to establish this. It is already the law of the land.

It is one thing, however, to have yardsticks identical in law. It is quite another thing to have them identical in fact.

If we recognize the legal identity of the British imperial yard with the American standard yard, the making of the yard bars of the United States identical in the *de facto* sense with the yard bars of England will then be difficult within the requirements of high precision. But if we assume that the standard yard of the United States is, as ordered by the Secretary of the Treasury in 1893, 103.5 millionths of an inch longer than the imperial yard, or is to be, as proposed by Mr. Bearce, 31.5 millionths of an inch longer than the imperial yard, then it becomes impossible to make the English and American yards identical.

And it is this pronouncement of the Bureau of Standards that the American inch is 3 millionths longer than the English inch that has been the cause of thirty years of controversy between the Bureau of Standards and the American industries which use high-precision inch dimensions in machine-tool manufacturing.

The question before the Bureau of Standards from the first has been, not whether 39.37, 39.370113, 39.370147, or 39.4 inches make a meter, but: "How many millionths of the meter of 1889 are there in a yard?"

In the latest edition of the "Encyclopedia Brittanica" (14th), Volume 15, on page 135 it is stated on the authority of the Bureau of Standards that: "The U. S. yard is about 3 parts in a million greater than the British yard." This statement is incorrect. The truth is clearly stated by such expressions as the following in Wentworth's "Advanced Arithmetic," edition of 1898, on page 154: "The standard yard of the United States conforms as nearly as possible to that of Great Britain." This is in accord with the formal statement issued by J. E. Hilgard for the U. S. Coast and Geodetic Survey, July 8, 1879, in which he declared, "There is no difference between the standards of length of Great Britain and those of the United States."

MILLIONTHS OF AN INCH

Now that we are talking in terms of millionths of an inch, it is in order to point out the variation between standard bars in terms of this ultimate unit.

There are no two measuring bars in the world between which the modern art of mensuration cannot detect differences under the microscopic comparator.

This fact is exemplified with respect to the 31 international-meter bars of 1889 which were generated from the same standard, ruled by the same method, but which upon calibration were all found to be different. Bar 6 was accordingly chosen as the meter, and the equations of the other bars with reference to Bar 6 were determined and certified.

There are four platinum-iridium "meter" bars at the U. S. Bureau of Standards, Nos. 21 and 27 of the alloy of 1889, and Nos. 4 and 12 of the alloy of 1874. Bar 4, the only one which carries a calibrated millimeter scale, was obtained in 1909; it also carries a special ruling or line to define the yard. A brief news item which appeared in the press at the time stated that the Bureau now had a bar upon which both the yard and the meter were ruled, and that the old yard standard of the United States would be discarded. The author was somewhat shocked at the time to think that the Bureau would assume the power to discard the yard standard of the United States. There was, however, no suggestion that the yard itself was to be discarded as the base for the inch, but the inference was that inch was to be taken as $1/36$ of this yard ruled on Bar 4. This yard ruling had been inscribed at Geneva and had been calibrated and certified by the International Bureau of Weights and Measures in Paris. It is assumed that this yard line had been ruled to conform to the value of yard found by the International Bureau and confirmed by the British Government.

A few years ago the author called on the Chief Physicist of the Bureau of Standards in charge of these bars and asked him if the Bureau had a platinum-iridium "meter" bar which also carried a definitive yard line. He promptly responded that there was no bar at the Bureau that carried such a line. A day or two later he called on and advised the author that a yard line had been found on Bar 4, who then requested and obtained a copy of the certificate of this bar. This incident is mentioned to show that the contemporary officials of the Bureau of Standards were not aware of this yard mark on Bar 4, which, of course, is just as much of a yard bar as a meter bar. As far as the author knows, no reference to this yard ruling on Bar 4 is to be found in the reports of the Bureau of Standards prior to a circular dated May 13, 1927.

The bars at the Bureau are not *meters*. Bar 21 is 98.4 millionths of inch longer than a meter, and Bar 27 is 63 millionths of an inch shorter. The difference between their lengths is 161.4 millionths of an inch. Bar 21 is certified at 1,000.0025 millimeters, and Bar 27 at 999.9984 millimeters.

The difference between the British standard at 914,399.2 millionths of a meter and the Bureau's yard at 914,401.83 millionths of a meter is 2.63 millionths of a meter. The difference between the Paris meter and No. 21 at the Bureau of Standards is 2.5 millionths of a meter, so that the difference

between the Bureau's yard and the real yard is comparably the same as between the Paris meter and the meter of Bar 21. The difference between these meters is a *de facto* difference which is scrupulously accounted in all precision comparisons. The comparable difference of 103.5 millionths of inch between the Bureau's yard and the legal yard is not a *de facto* difference that can be corrected by accounting. It is an "official" difference which can be corrected only by abrogating the error which is the cause of it.

It is one thing to contend that the arbitrary elongation of American line standards by 2.875 millionths is negligible, but quite another to hold that it constitutes a legal difference between the fundamental linear units of England and the United States.

It must be frankly stated that it is easier to reproduce 914,399.2 millionths of the meter of 1889 than to reproduce 1,000,000 millionths of the yard of 1844. It would be a simple thing, however, for the Bureau of Standards to *take 1,420,212 wave lengths of the red ray of cadmium as the generative value for the yard*, and 914,399.2 millionths of a meter as the test or reference value.

INCHES AND MILLIMETERS

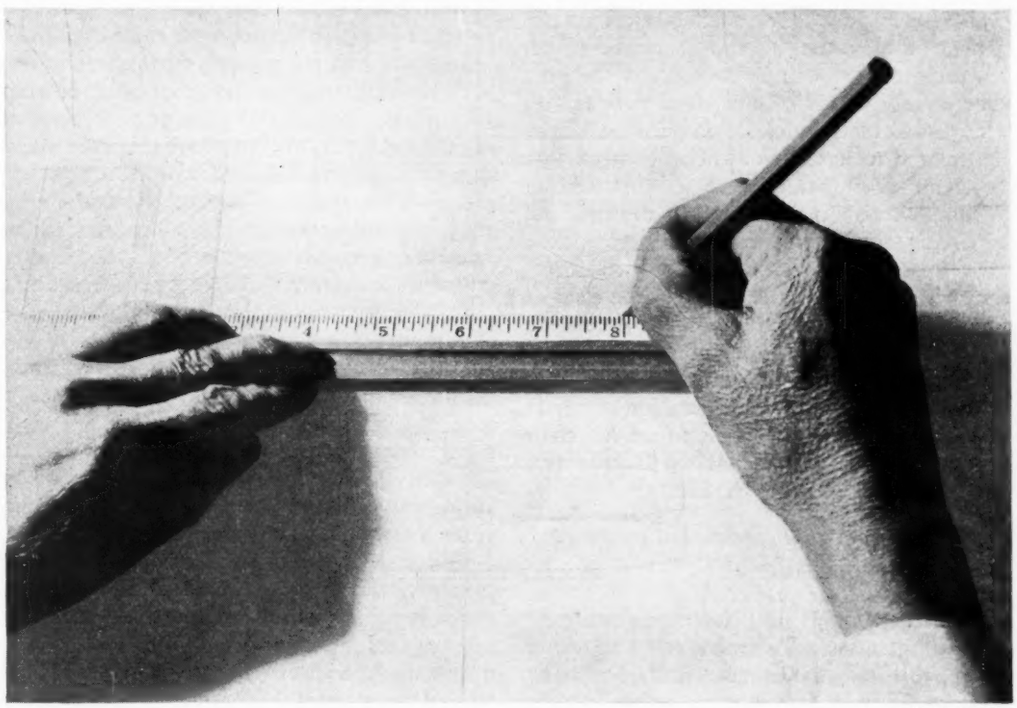
The practice of the American machine-tool trades has been to generate 25.4 millimeters from the inch in manufacturing to millimeter specifications. But the Bureau is strongly opposed to any change in the wave-length definition of the meter that would make 25.4 millimeters exactly equal to one inch. Those of us who have held opinions contrary to those of the Bureau of Standards have no concern with the number of wave lengths in a meter. We accept 1,553,164.13 wave lengths for the meter as a finality. We stand for 1,420,212 wave lengths for the yard. We stand for the ultimate yard-meter ratio made by these figures in common wave-length denomination. We accept 25.4 as the proper inch-millimeter conversion ratio for shop practice. If any manufacturer wants to generate 25.4 millimeters from the inch, let him do so. If any one wants to derive his millimeters straight from the meter, let him get them that way. The difference is 0.034 millionth of an inch per millimeter.

We do object to making the inch dependent upon the metric system. We stand for a definitive inch equal to $1/36$ yard and against one of 25.4 millimeters. Mr. Bearce proposes to obviate this by making the yard definitively 914.4 millimeters. This is equally objectionable and unacceptable. His proposal calls for an elongation of the yard by 31.5 millionths of an inch. And that is the end of the argument.

The yard is the yard. It is a standard. The inch is the $1/36$ part of the yard. The yard is not a multiple of 36 inches, it is an independent entity. The Bureau takes the inch as definitively $1/39.37$ of a meter instead of $1/36$ of a yard, and then builds up a yard from this derived inch which is 103.5 millionths of an inch longer than the legal yard. We are therefore opposed to a definitive inch of 25.4 millimeters from which to build up a foot that is 10.5 millionths of an inch and a yard that is 31.5 millionths of an inch off the legal standard.

American industry requires a precise and independent definition for the inch. The imperative thing, in the absence of a United States yard standard, is for the U. S. Bureau of Standards to take the wave-length value for the yard which conforms to the legal value of the imperial standard yard of Great Britain. To bring everything to rights, let us generate a United States standard foot from 473,404 wave lengths of red cadmium light, generate 12 inches from the foot, and generate 25.4 millimeters from the inch.

And then let us petition Congress to protect the integrity, independence, and exactitude of the American inch of this value.



H. E. Angell

MECHANICAL ENGINEERING

Vol. 55 MARCH, 1933 No. 3

GEORGE A. STETSON, *Editor*

Wages and Prices

MR. EARNEST T. WEIR, chairman of the board of the National Steel Corporation, is reported to have said recently that wages in the steel industry should not be reduced, and to have made the point that a further cut in wages might well result in a slackening of demand for steel in anticipation of a corresponding reduction in prices.

Commenting on the reduction of wages in the steel industry that took place in 1931, MECHANICAL ENGINEERING said, editorially, in its November, 1931, issue:

"It does not take buyers long to figure out that a cut of wages means a lower cost of production, and that a lower cost of production should mean a lower card of prices. Thus the saving in wages may be reflected in a general lowering of prices in the basic industries where wage reductions have been brought about."

The Tennessee River System

PRESIDENT-ELECT ROOSEVELT'S interest in the development of the valley of the Tennessee River, recently given prominence in the press, recalls the very able survey of this region carried out some years ago by the U. S. Army Corps of Engineers. Particulars of the survey, which related to navigation, flood control, and power-development possibilities, were set forth in an article by J. A. Switzer, professor of hydraulic and sanitary engineering, University of Tennessee, in the September, 1929, issue of MECHANICAL ENGINEERING. Professor Switzer's article contained an outline map of the region on which were shown the location of existing and proposed hydroelectric power and reservoir projects, as well as a table giving the cost and selling price of output for the power system in consideration of power development only. Readers who wish to refresh their minds on the principal data of the Tennessee River system are directed to Professor Switzer's article.

Intellectual Maturity Assumed

THERE are few persons as dull and uninspiring as the cautious dogmatist who insists that nothing shall be said or published that is not tritely orthodox and vapidly safe. While we do not aspire to become purveyors of distinctive philosophies or to be classed with those who smash idols for the pleasure they experience in hearing the noise of shattering plaster, we do assume that readers of MECHANICAL ENGINEERING are sufficiently mature intellectually to consider without damaging effects new or unorthodox views logically expressed by those who hold them as sincere convictions. It should not be necessary, although surely there can be no harm in doing so, to remind readers that the articles published in MECHANICAL ENGINEERING express the personal opinions of their authors. If they stimulate thought and further study of the problems involved they will have served their purpose, regardless of the validity of their conclusions and even if they may provide shocks to complacency. It is unlikely that engineers, who deliberately pick out facts from fancies in the course of their daily practice, are intellectually so immature as to be unable to preserve reasonable stability under the impact of ideas that may be new to them.

German Circle of English-Speaking Engineers

REPORTS have been received in this country of the successful inauguration of a series of meetings of English-speaking engineers, known as the Zirkel English-Sprechender Ingenieure, at the headquarters of the Verein deutscher Ingenieure in Berlin. Dr. G. de Thierry, professor emeritus of Charlottenburg University, acted as chairman at the opening meeting, and delivered an address of welcome in English. Mr. Loughnan Pendred, editor of *The Engineer*, past-president of the Institution of Mechanical Engineers, delivered the principal address. Meetings of the British group in London, at which Dr. Matschoss spoke, and of the German group in Berlin, have since been held.

In times like the present when nationalism has taken such decisive steps to keep alive the differences in customs, traditions, and language that have always been stumbling blocks to international peace and understanding, Professor de Thierry's words are worthy of emphasis. "It is our sincere desire," he said, "that our meetings may contribute to stimulate personal and friendly relations between engineers of the English-speaking countries and German engineers. Technical science has connected space and time with unlooked-for success. We ought, however, not to be contented with the solution of technical problems, however interesting and profitable these solutions may be. There is, beyond this side of our activity, an obligation for all bearing the name of engineers to endeavor to make technical progress advance the welfare of all humanity. Personal relations between man and man are the preliminary conditions for attaining this aim and end."

The understanding of the points of view of another race may never be so complete or so convincing as to make wars impossible. That it greatly mitigates the intensity of blind passion that arises whenever international differences become acute, has been demonstrated many times. Whatever assists this understanding should be carefully cherished, and this interest in language that is being fostered by the Zirkel is a factor

of importance in this connection. The American Society of Mechanical Engineers has kindly offered the use of its rooms to any group of engineers who would like to organize such a movement in this country.

Engineers and Planning

ENHEARTENING evidence of the making of the best of bad times is to be found in an interesting booklet describing the emergency relief work of the engineers and architects in the Boston metropolitan area through the medium of an organization known as the Emergency Planning and Research Bureau, Inc. Prefaced by a letter from Governor Ely in which he acknowledges and praises that organization for giving practical and effective assistance to state departments in the form of data that would not otherwise have been available, and by a statement by Philip Cabot, one of the Bureau's advisers, in which the great value of the work accomplished is emphasized, the booklet tells briefly of the formation and activities of the Bureau and lists what it has done and the organizations for which it has worked.

The Bureau was formed by the architectural and engineering societies of the Boston metropolitan district to provide some means of caring for their own members. Funds to the extent of more than $112,000 were raised among those able to contribute, administration expense and overhead were rigorously maintained at a minimum so that 96 cents out of every dollar subscribed was paid out in wages, and 389 worthy individuals from 1322 applicants were directly employed, and positions obtained for 171 more.

But most interesting of all is what these men did. A major portion of their work consisted in fact-finding surveys and studies of projects and conditions within the district on which information was necessary but for which no funds were available. State and city commissions, institutions, and boards needed these data, as well as professional and welfare groups. It is stated that for less than one-fourth of the expense incurred in certain other large cities where similar information has been collected, the Bureau has been obtaining the basic facts which must be used if planning of the metropolitan area is to be carried out on the scale found necessary in other communities. The facts determined in these studies make it possible for the community to defend itself against political pressure and waves of public sentiment to expend funds to achieve unwise or selfish ends. With the facts determined, competent men can make wise decisions in regard to the future of this section of the state. By-product advantages to the individual institutions involved and to certain specific business problems of retailing and advertising are also evident. Thus in its endeavor to assist the unemployed engineers and architects by providing for their work within their sphere of interest and ability, the Bureau has rendered a valuable service to the community.

In another booklet on unemployment relief funds for public works, prepared by the engineering societies of Boston assisted by the Emergency Planning and Research Bureau, Inc., a statistical study of the public-welfare expenditures for some 40 municipalities in the Boston area from 1921 to 1932 is presented, together with an analysis of the unemployment-relief activities of these same districts. It is shown that in 1932 the expenditures in this area were nearly $5,000,000 in excess of what they normally would have been except for the widespread unemployment caused by the present depression.

The Model Registration Law

THE model law recently approved by the Council of The American Society of Mechanical Engineers, is that mentioned from time to time in MECHANICAL ENGINEERING as being developed by a committee of the American Society of Civil Engineers in cooperation with many other engineering organizations, and revised and approved by representatives of these bodies on April 15, 1932. Prepared by professional engineers and subjected to careful examination as it has been, the model law provides a thoroughly developed starting point for any group of individuals who may find themselves charged with the duty of writing or revising a law covering the registration of engineers.

Engineers have not been, nor can they be, supinely apathetic about legislation that affects their right to practice their chosen profession. Regardless of personal prejudices for or against legislation of this type, certain practical questions are involved. An engineer should be familiar with the laws concerning his profession already in existence, and every individual should act in accordance with facts as they affect him. Should he find that he, as an individual, need not register under existing laws, although permitted to do so, he should reflect, before deciding not to register, on certain pertinent factors. History shows clearly that registration is becoming more widespread as time goes on, and that new and revised laws are more comprehensive and exacting than the earlier laws. Teeth have been put into some state laws, and indications are that the teeth are to be used. "Grandfather" clauses do not run on forever. Promotion or a change of position may change an individual's status with respect to the requirements of the law.

In states where registration laws are being proposed, or where revisions are in order, engineers will perform a public service, in addition to looking after their own interests, by bringing the model law approved by the engineering societies to the attention of those in charge of the new legislation. The desirability and practicability of a properly drawn law are emphasized when the reciprocity clauses that are usually a feature of such laws are considered. If a registration law is to be enacted and enforced, it is to the interest of engineers that it be a means of raising and maintaining the standard of engineering practice and of safeguarding the public against charlatans and incompetents.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See Internal-Combustion Engineering: The 80-Hp Pobjoy Aero Engine)

ENGINEERING ECONOMICS

Secondary Effects of the Depression in England

WHILE the immediate or obvious effects of trade depression cannot escape attention, there are others, less clearly to be seen, which threaten a future danger. The most serious of these is the direct outcome of excessive taxation at a time when the turnover of money is curtailed. When direct taxation is low, prudent firms, even though trade be bad, put something to one side for developments and research. But when 25 per cent of what small profits they can make now has to be surrendered to the state, nothing can be retained for that very essential work. Furthermore, heavy taxation of the individual checks industrial investments and, combined with the small inducements which the returns on such investments offer, dams the flow of money to manufacturing industries. There are, we fear, little or no grounds for even hoping that the Chancellor of the Exchequer will be in a position to decrease the income tax this year, but if, in consequence of bad trade, he is tempted to raise it still further, the result will be disastrous to industry.

Another of the secondary effects is the difficulty of training the young men of all classes who must carry on the engineering industries in the near future. The number of trade lads who should be serving their time is very much smaller than it ought to be, while graduates from colleges who should now be receiving their works training, experience such difficulties in finding employment that they are turning to quite other occupations. In these matters the Government cannot do much, but toward the end of the year several firms in Great Britain took steps to meet the problem, and there is little doubt that schemes under which alternate weeks are worked by apprentices could be developed. (Part of an editorial entitled, "1932—A Retrospect," in *The Engineer*, vol. 155, no. 4017, Jan. 6, 1933, p. 18, *g*)

ENGINEERING MATERIALS

Sintered Tungsten Carbide Brinell Balls

IT IS STATED that accurate tungsten carbide balls have recently been produced in the United States through the cooperation of the Carboloy Co. and the Atlas Ball Co. The rough ball blanks are furnished by the Carboloy Co., while the Atlas Ball Co. has developed a grinding method whereby these extremely hard, rough blanks are ground to within an accuracy of diameter and sphericity of better than 0.000025 in. Tests were then undertaken to establish the relationship between Brinell numbers obtained with this new ball and those with the Hultgren ball (described in the Proceedings of the American Society for Testing Materials, Vol. 24, II, 1924, p. 304) with the Rockwell diamond cone number and the Vickers pyramid numbers obtained on the same materials. The results are given in the form of tables and curves. The impressions made with carboloy balls are said to be much easier to read under the microscope than those made with the Hultgren balls, particularly on harder materials. This was particularly evident on tantalum carbide. The average values obtained with the 5-mm carboloy balls are consistently higher than those obtained with 5-mm Hultgren balls, and the difference increases with greater hardness of the sample, but the average points are not more than 10 per cent over Petrenko's curve.

In ordinary practice it is most convenient to use the ball in a fixed position in the holder, and a conversion table for Rockwell C to Atlas-Carboloy ball should therefore be based on the values represented by the dotted line in the graph. The Carboloy ball would then give consistent results on material softer than 67 R.C. after a few preliminary impressions on the hard material. The Carboloy should not be used for harder material than about 67 on account of the greater deformation. Similarly, a Hultgren ball for general application should not be used for impressions on material over 62 R.C.

Thee rlation between Vickers pyramid number, 30 kg load, and Brinell readings with these two types of balls as well as with Rockwell C 150 kg, is shown in a graph in the original article. It is quite evident from this graph that the readings obtained with the Carboloy ball come much closer to being proportional to the Vickers P.N. than the Hultgren or Rockwell readings.

A further test of interest was made on the Carboloy ball. After 100 impressions on disk 5 the ball was turned slightly so that the first flattened portion would intersect a new impression. While the impression now became irregular in shape, the mean of the long and short axes still read about the same hardness as before, namely, 795 for 10 impressions on disk 5.

Carboloy balls have also been used to advantage for hardness testing at temperatures up to 1600 F, and no softening has been experienced. (Haakon Styri, Director of Research, SKF Industries, Inc., in *Metals and Alloys*, vol. 3, no. 12, Dec., 1932, pp. 273–274, 4 fig., *ec*)

A Method of Increasing the Wear Resistance of Cast Iron

THE author claims that if cast iron is annealed at 500 C in ordinary atmosphere, the resistance to wear greatly increases, whereas its structure and mechanical properties remain practically unchanged. He attributes the cause of increase of wear resistance to the internal oxidation of cast iron by oxygen in the ordinary atmosphere, and supports his statement by the observation that the same treatment carried out in non-oxidizing gases does not show any improvement of wear resistance. (Ichatara Takaba, Engr., Mitsubishi Shipbuilding & Engrg. Co., Nagasaki Works, in *Journal of the Society of Mechanical Engineers, Japan*, vol. 35, no. 188, Dec., 1932, pp. 1180–1190, 27 figs., in Japanese, *p*)

Thermal Expansion of Lead

MEASUREMENTS have been made on the linear thermal expansion of cast lead between room temperature and 300 C and the results compared with previously obtained

data. The results are presented in the form of tables and curves.

The average coefficients of linear expansion for various temperature ranges between —250 C and +300 C, as derived from the expansion curve in Fig. 2 (not reproduced here) are as follows:

	$\times 10^{-6}$
—250 C to +20 C	25.1
—200 C to 20 C	26.5
—100 C to 20 C	28.3
+ 20 C to 60 C	28.8
20 C to 100 C	29.1
20 C to 200 C	30.0
20 C to 300 C	31.3

(Peter Hidnert and W. T. Sweeney in *U. S. Bureau of Standards Research Paper* no. 500, reprinted in *Bureau of Standards Journal of Research*, vol. 9, Nov., 1932, pp. 703–709, 2 figs., *e*)

Refractory Service, With Particular Reference to Boiler Furnaces

ONLY a brief abstract of this extensive and interesting article can be given because of space limitations.

There are several "refractoriness tests" which have been developed by different workers. The refractoriness figure obtained varies with the actual test made, and when comparing with published refractoriness figures, care must be taken to see that the results under consideration have been obtained under comparable conditions. The results obtained are dependent, for example, upon the rate of rise of temperature during the test. The quicker the rise of temperature, the higher will be the point of failure. The atmosphere of the test furnace will also influence the result, a reducing atmosphere in many cases giving a lower figure than a more oxidizing one.

Several tests have been developed to determine the rigidity of refractories at high temperature, the results of which are usually published as "refractoriness under load." These published "under load" figures should be accepted and compared with some caution, though when all the data are available for consideration, the performance of the brick under load may be a very valuable criterion of its quality. The results obtained, however, will vary greatly with the rate of heating, the size of test piece, and the atmosphere in the test furnace, and will be a function of the pressure applied. The standard test now used at the North Staffordshire Technical College consists briefly of a test piece $3\frac{1}{2}$ in. × 2 in. × 2 in. which is submitted to a load of 50 lb per sq in., and heated at the rate of 50 C per 10 min. The expansion, and ultimately the subsidence, is noted at intervals, from which data a curve may be plotted. The figure given as the "refractoriness under load" is usually the temperature at which subsidence reaches 4 in. below the zero on the indicator scale, which magnifies 16 times, and therefore represents an actual subsidence of about $\frac{1}{4}$ in. This test is, perhaps, apt to err a little on the safe side.

A clearer and more valuable picture of the properties of a refractory under consideration may be obtained by an examination of the whole curve showing its behavior during the test. Appreciable differences occur with various fireclays, and the amount of the various impurities usually present in a fireclay may have a powerful effect upon the results. Fig. 1 shows two types of curve which may be obtained; curve A is typical of a high-grade Scottish firebrick containing 44 per cent alumina. There is a point (*a*) at which the curve stops its upward trend, gradually flattens out, and slowly begins to subside, while at the second point (*b*) rapid collapse sets in. Curve B is typical of a semi-silica firebrick, made from a class of fireclay which may contain 75 per cent to 85 per cent SiO_2, i.e., with a large percentage of free silica present as an impurity. It will be seen that, while the point (*a'*) is higher than with more aluminous and refractory clays, the range (*a'*) to (*b'*) is much shorter and complete collapse takes place more suddenly and at a lower temperature than with the more aluminous clays.

Lime, magnesia, and alkalis, particularly the former, greatly reduced the rigidity of fireclays under load at high temperature. The effect of other impurities is discussed in detail. The matter of semi-silica brick is particularly interesting.

A type of super-refractory which has excellent load-carrying properties at high temperatures is the sillimanite-base refractory, but bricks of this material do not appear, however, to be particularly resistant to erosion by highly ferruginous slags (especially where the atmosphere is reducing), and where these conditions are also encountered are unlikely to justify the extra cost. This property that properly bonded and burnt sillimanite bricks possess, of withstanding loads at high temperatures, will be understood if reference is made to the alumina-silica fusion diagram, where it will be seen that there is an aluminum silicate corresponding to the formula $3Al_2O_3$-$2SiO_2$, which is a definite crystalline compound known as mullite, possessing a true melting point of approximately 1810 C. Now, the raw material for sillimanite bricks, whether it is natural sillimanite, cyanite, or andalusite, is thoroughly calcined before use and inverts to mullite and excess silica. Hence, when this material is taken bonded with a suitable clay and thoroughly burnt, the resultant brick contains a high proportion of mullite crystals having, as mentioned above, a definite melting point; so that at those temperatures at which an ordinary firebrick is softening due to the formation of a high proportion of "glassy" material, the sillimanite brick contains much less glass and is correspondingly stronger and more rigid.

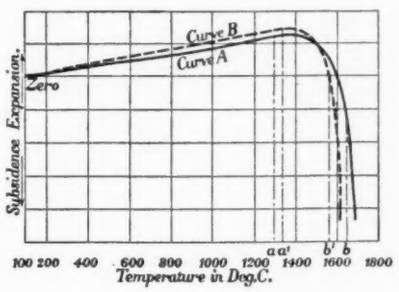


FIG. 1 CURVES SHOWING THE BEHAVIOR OF A REFRACTORY UNDER TEST FOR "REFRACTORINESS UNDER LOAD"

These sillimanite bricks, as mentioned above, are not particularly resistant to attack by highly ferruginous slags, the explanation being that when the cyanite, andalusite, or sillimanite is calcined before use, the mullite crystals and excess silica are formed as explained previously, and these products are crushed and bonded with clay. The brick formed therefore consists of broken mullite crystals with a glassy matrix formed from the clay bond and excess silica. It is this matrix which is readily attacked by ferruginous slags, and the loose mullite crystals are then easily eroded away.

This weakness is absent from a type of highly aluminous brick containing a high proportion of grog prepared by thorough calcination of picked Ayrshire bauxite clay. A factor to which possibly less thought is given than it deserves is abrasion. The resistance of a brick to abrasion depends upon its physical characteristics, such as its hardness, also on the toughness of the bond, the tenacity with which it grips the grog, and the size and shape of the grains of the material forming the brick. A coarse structure in which large grog grains are loosely held is abraded readily, while a sandy or

"balled" structure would also be likely to give poor results. The best results are obtained from bricks made from material with a gristing or mesh containing a suitable balance of all sized grains that packed together well, the grains being sharp and angular.

Both air- and water-cooled walls offer the advantage of increased resistance to abrasion due to the fact that the refractory is kept at a much lower temperature than in an ordinary wall, hence retaining greater strength and hardness; while, more important still, in a well-cooled wall a layer of chilled slag may form on the refractories and act as a protective coating.

Thermal and physical spalling are discussed in detail. The former is caused either by the stresses set up due to a very steep temperature gradient through the refractory, or more usually by rapid temperature changes. The first is likely to occur in cooled walls or arches, particularly where water is the cooling medium. Physical spalling is caused by changes in the refractory in service which modify its physical properties in such a way as to cause cracking. The slags are particularly effective in this connection. There is a further type of cracking which may be called mechanical spalling, and is caused by localized mechanical stresses, such as pinching. This is apt to occur, for example, in spring arches, where the arch bricks are braced up between the skewbacks at either side and where on heating the arch must rise a little on account on the reversible thermal expansion of the refractories. Such a rise decreases the ratios of curvature of the arch, subjecting the inner ends of the arch bricks to a compression, and the flatter the curvature of the arch, the greater are the stresses set up.

For really high-temperature work, such as may be encountered in oil-fired combustion chambers, arch bricks of a good, highly aluminous brand should be chosen, with the setting faces ground flat, and set with a thin wash of highly refractory cement, the arch being built with as generous a curvature as possible.

Slagging is one of the most important causes of failure, but one which, in view of its complex nature, is hardest to deal with, and about whose fundamental principles the least is known. The author considers slagging first as a chemical reaction and then from the point of view of the viscosity of the slag formed, as this influences the velocity of the movement of the slag on furnace walls and arches.

It is obvious that the greater the velocity of the slag over the refractory face, the more rapidly is fresh slag brought up to the attack and the more rapidly does the refractory wear away. The greater the viscosity of the slag, the slower will be its movement over the refractory face. Similarly, the viscosity influences the rate of diffusion, both of gases through the slag and of the products of reaction in the slag. Incidentally, it is worthy of note that the great value of aluminous firebricks in resisting slag attack is in part due to their influence on these factors which have just been considered. The more highly aluminous a firebrick is, the more mullite crystals or the more mullite-forming material it contains—i.e., a material whose crystals we have already mentioned dissolve or redissolve least readily in the glassy material of the slag. The rate of reaction between this class of brick and coal-ash slag is slower than for more siliceous bricks. Furthermore, the effect of solution of aluminous firebricks is to increase the alumina content of the coal-ash slags, which are, in general, impure aluminum silicates of such a composition that an increase of alumina content increases the refractoriness of the slag and also renders it more viscous, so that its corrosiveness is greatly reduced.

It has been remarked previously that a reducing atmosphere may greatly decrease the refractoriness and strength under load of a fireclay refractory, but it may have an even greater effect upon the resistance of slag attack, in that it reduces the iron compounds, both of the coal ash and the products of reaction between the ash and the refractory, to the ferrous state, giving ferrous silicates which melt at lower temperatures, thus producing a more fluid and corrosive slag. Experience offers strong support to this theory and, in furnaces where strongly reducing conditions obtain, it is usually found that the refractories have a correspondingly high rate of wear. The furnace atmosphere is to some extent under the control of the operators. For example, in furnaces burning solid fuels, with chain grates, retort stokers, etc. the employment of an extra-thick fuel bed results in high temperatures and a more strongly reducing atmosphere, so that refractory life is usually short under these conditions. With pulverized fuel, gas, or oil fuels, the atmosphere will be controlled by the balance of the amount of fuel blown in and the amount of air (primary or secondary) admitted for its combustion. The furnace atmosphere can therefore be made less strongly reducing and conditions less severe for the refractories by using a higher proportion of excess air, which, however, is apt to result in a decrease of boiler efficiency, due to higher stack losses. In some cases, however, the overall plant efficiency may be maintained by the benefit arising from the higher superheated-steam temperatures obtainable.

In general, slag attack consists of a chemical reaction roughly of the nature which has been outlined, the destructive power of which may be influenced by such factors as the rate of reaction between the fuel ash and the refractory, surface tension and viscosity of the slag, furnace temperatures, impingement of flame and furnace gases, permeability of the refractory and the amount of erosion accompanying the reaction, etc. Hence it is rarely found that a refractory and slag interface conforms exactly to the description outlined earlier for the "theoretically perfect case" of slag corrosion.

The concluding portion of the article deals with fabricated walls, furnace arches, air distribution under the grates, troubles due to local gas velocities, and the use of comparatively thin side walls in cased boilers. Among other things, the author describes a new furnace design which consists essentially of a rear fireclay panel wall and a similar paneled silicon carbide front wall built with the recessed faces toward one another. This arrangement enables the direction of flow of the cooling air to be definitely controlled, the cooling medium being split up into a multiplicity of streams, each with its own clear marked path across the wall. Furthermore, by the spiral and turbulent flow which may be imparted to the cooling air, pocketing is eliminated, and the air being forced on to the back face of each silicon carbide panel, destroys any tendency there may be for a hot-air film or layer to adhere to the face of the blocks.

Only the silicon carbide inner wall should need replacement, and the outer fireclay should last out a number of inner linings. The principle of this inner wall is also applicable to furnace arches, particularly sprung arches. (John Walker in *Engineering*, vol. 135, nos. 3495 and 3496, Jan. 6 and 13, 1933, pp. 4–7 and 33–37, 11 figs., *dc*)

FOUNDRY

Reclaiming Leaky Castings

THIS article describes a method used for salvaging imperfect castings where the matter of strength is not involved and it is merely desired to eliminate excessive porosity and blowholes. The method is thus recommended only for salvaging

"weeps" and "sweats." It consists in the treatment of a casting with a phenol formaldehyde resin (generally known as bakelite). It comes in the form of a liquid compound which is forced into the pores of the metal under pressure until it shows up on the outside of the casting, the pressure used being between 200 and 300 lb per sq in.

After removing the excess varnish from the surface the casting is baked at a high temperature to polymerize or condense the compound, thus changing it chemically and thereby producing an insoluble product in place of the initial soluble one: a product inert to caustic soda, washing soda, ordinary acids, hot water, etc.

There are several varieties of resinous products that will react similarly to phenol formaldehyde to form a condensation product which are in use for some of the manifold purposes to which bakelite is put. Some of these in varnish form might be used for plugging leaks, but the details of their application for this purpose have apparently not yet been worked out.

There are two types of sealing solutions. One is made up without filler and the other contains a suspended inert filler. When reclaiming pressure castings of brass, bronze, nickel silver, and high-shrinkage alloys where the leakage is caused by porosity and the imperfections are extremely minute, a solution of phenol formaldehyde resin and alcohol without filler should be used. This solution can be forced into the smallest pores and hardened in place, and castings thus treated can be expected to give the same results as perfect castings in normal service.

When reclaiming castings of aluminum and aluminum alloys a solution containing inert filler suspended in phenol formaldehyde resin and alcohol is especially useful.

It is very essential that the proper compound be selected. One containing filler would be most objectionable if used on brass, bronze, white metal, etc. as the filler would clog the leaks at the casting surface and the sealing solution could not penetrate sufficiently. On the other hand, a compound without inert filler in solution would have no effect at all on the larger flaws of aluminum castings.

The question has been raised as to whether the difference in coefficient of expansion of the sealing compound and the metal of the casting will cause the leaks to open up. This is a remote contingency because the intercrystalline flaws are extremely irregular and very tiny. Castings treated with these solutions have been tested under various conditions and put back under pressure with entirely satisfactory results.

The details of the process, including sketches of installations, are described in the original article. The cost of installation is estimated at from $150 to $500. (W. M. Corse, Metallurgical Engr., Washington, D. C., in *Metals and Alloys*, vol. 3, no. 11, Nov., 1932, pp. 255–256, 3 figs., *pd*)

INTERNAL-COMBUSTION ENGINEERING (See also Railroad Engineering: Streamlined High-Speed Car of the German National Railroad Company)

The Jameson Supercharged Two-Stroke Engine

ONLY a single-cylinder unit of this type has been built with a net capacity (measured above the piston-controlled exhaust ports) of but 411 cu cm. It is said that it has proved capable of exceeding 5000 rpm and of reaching an output of 50 bhp, which represents a brake mean effective pressure greater than that usually obtained in a four-stroke engine. The author of the article states that he has examined the working parts of this engine stripped after running on the test bed for a very considerable time, and found no signs of undue wear or overheating.

The principle of construction is shown by Fig. 2, which is a diagrammatic cross-section of the engine. The admission of the mixture is controlled by a simple piston valve in the head driven by a crank and short connecting rod from a layshaft running at crankshaft speed. The crank is so short that it can rotate within the hollow valve, in this way providing a compact design.

The cylinder in which the piston valve reciprocates is provided with a ring of inlet ports, beneath which there is an almost spherical combustion chamber fitted with a spark plug. The chamber communicates with the cylinder through a narrow venturi orifice. The head of the piston is made of conical shape to match the cylinder head, and only a small clearance remains between the surfaces at top dead center. When near to the bottom of its stroke the piston uncovers a ring of exhaust ports.

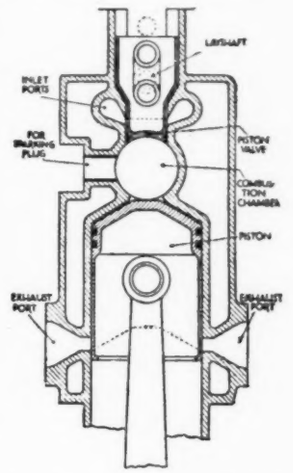


FIG. 2 CROSS-SECTION OF THE JAMESON SUPERCHARGED TWO-STROKE ENGINE

As regards timing, the best results have been obtained by allowing the inlet ports to open shortly before the piston reaches bottom dead center. The mixture is admitted under pressure from a supercharger until the ports are closed by the piston valve some 90 deg after bottom dead center. It is then compressed, the ratio being seven to one, and a very high degree of turbulence is obtained by the expulsion of the gases from the cylinder through the venturi at the top.

An important point is that during the processes of final compression and combustion the piston valve is practically stationary owing to the way in which it is driven by a very short connecting rod. On the other hand, the geometry of the drive is such that the valve is traveling at maximum speed when the ports are being opened and closed, thus insuring the rapid admission and cut-off essential to the proper filling of the cylinder with mixture at high speeds. Again, the crank which operates the piston valve is on dead center when the maximum pressure is reached in the cylinder, thus presenting an almost "solid" support.

It is stated that a special type of supercharger has been evolved for this engine. In one of the types it is to be located in the drive between the crankshaft and the layshaft. (*Motor*, vol. 62, no. 1614, Nov. 29, 1932, p. 800, 2 figs., *d*)

The 80-Hp Pobjoy Aero Engine

THIS is a radial air-cooled engine and its description in the article here abstracted is introduced by a statement to the effect that it is no exaggeration to say that Great Britain leads the world in light-airplane construction, and that, apart from J. A. Mollison's successful crossing of the Atlantic in August, 1932, many remarkable flights have been achieved in British machines of this type. The major credit for these flights is given to the engine builders, and it is noteworthy that while there are no British light airplanes now built fitted with foreign engines, British engines are widely

employed in small foreign craft. In this connection particular attention is called to the Pobjoy model R engine.

The cylinder bore is 77 mm and the piston stroke 87 mm, giving a capacity of 2835 cu cm. The rated output is 75 bhp at 3000 rpm, corresponding to 1400 rpm for the geared airscrew, but the engine will give a continuous output of 80 bhp at 3060 rpm, rising to 85 bhp at 3300 rpm as a maximum. The weight of the engine, including the airscrew hub, hand starter, full dual ignition, and short exhaust pipes, is 135 lb, or 1.7 lb per rated horsepower.

The crankcase is of aluminum alloy and is in four parts consisting of two central portions, one carrying the cylinders

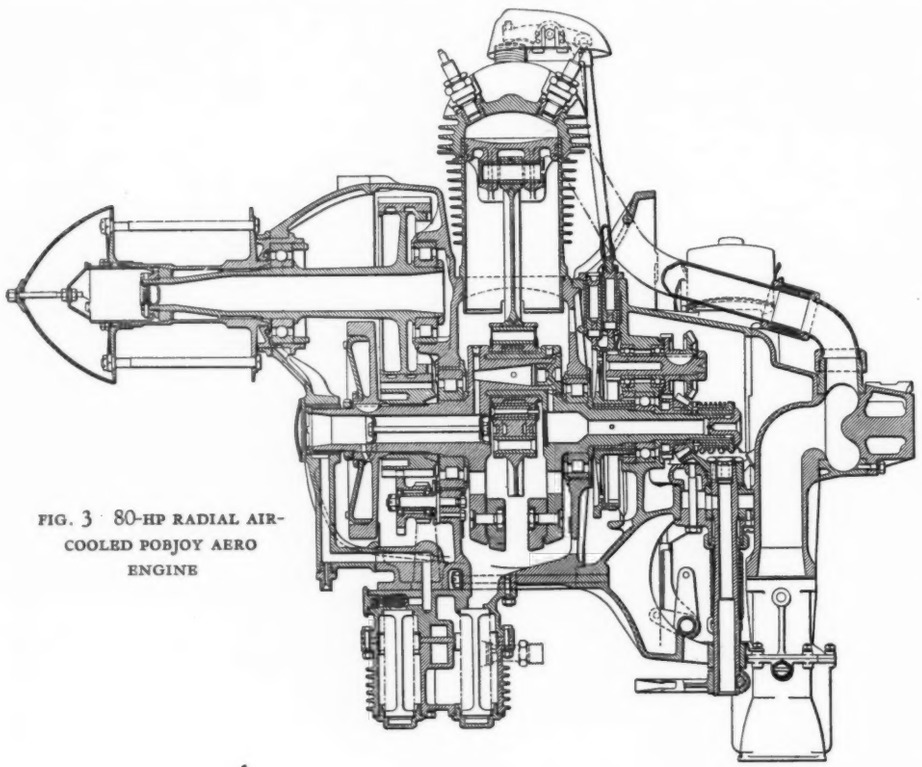


FIG. 3 80-HP RADIAL AIR-COOLED POBJOY AERO ENGINE

and the other enclosing the valve-operating gear and two end pieces. The crankshaft is of the single-throw type, built up in two pieces, and is carried in four bearings. It is drilled for lightness. The airscrew is geared by a pair of double-helical wheels with a reduction ratio of 2.13 to 1, the screw being off center. No trouble from uneven cooling of the cylinders was experienced. Two synchronized independent ignition systems are used, each consisting of a magneto and high-tension distributer with separate plugs in each cylinder. The magnetos are driven from the end of the crankshaft.

The lubricating system for the engine is of particular interest. The oil pump is mounted on the front of the engine at the base, as shown in Fig. 3 and in another illustration in the original article. A wheel with helical teeth, mounted on a short horizontal shaft above the pump, engages with one side of the main double-helical gearwheel on the crankshaft. The smaller wheel is formed in one piece with a skew gear, and this engages with a corresponding skew gear at the top of the pump shaft. As shown in Fig. 3, the compound wheel runs on ball bearings. The pump shaft is not shown in the figure, but the tapered column in which it is mounted is shown by dot-and-dash lines. The pump is of the gearwheel type, with two sets of wheels which serve as pressure and scavenge pumps. The oil from the tank is fed into the left-hand bottom filter chamber, and is delivered into the upper of the two central rectangular ports, at a pressure of 35 lb per sq in., by the pressure pump. From this port it passes along the passage shown to the front crankshaft bearing, and thence into the center of the crankshaft. The hole in the latter is stopped off by a cup washer a short distance from the end, and this washer diverts the oil through a port into the interior of the flywheel, which constitutes a centrifugal filter. The oil reenters the crankshaft behind the washer, and after passing through the crankpin is delivered to the interior of the rear half of the shaft.

Radial holes through the crankpin and shaft feed the big-end and cam-plate bearing, and the oil reaches the low-pressure side of the system through these bearings, the plain front-end bearing, and a small hole in the rear end of the crankshaft. The space surrounding the lower half of the flywheel and the gear driving the pump acts as a receiving chamber, into which the flywheel and main gearwheel on the crankshaft dip, so that an abundant supply of oil at low pressure is thrown on to the two bearings of the airscrew shaft. The cylinder walls are lubricated by the spray from the ends of the big-end bearings, and the same supply serves for the gudgeon pins. An opening in the wall of the crank chamber allows the oil to pass to the valve tappets, while the supply leaving the ends of the cam-plate bearing lubricates the two rear bearings on the crankshaft and also the camshaft bearings. The oil from the bearings, and from the receiving chamber referred to, drains into the right-hand bottom filter chamber shown in Fig. 3, from which it is delivered by the scavenge pump into the lower of the two rectangular ports, and is finally returned to the tank. The bearings for the valve rockers are dustproof, and are packed with grease. A grease-gun attachment is provided for replenishing the latter at intervals. (*Engineering*, vol. 134, no. 3488, Nov. 18, 1932, pp. 594–595, 4 figs. and plate on p. 598, *dA*)

LIGHTING

An Induction Mercury-Vapor Lamp

CHARACTERIZED as an inductively energized lamp, a new form of gaseous-discharge source suitable for television, therapeutics, sun lamps, photography, floodlights, motion-picture projection, and similar purposes has been developed at the Myers Electrical Research Laboratory in New York.

The lamp there shown, which is said to generate 250,000 cp, creates light by the dissociation of the mercury atom, accom-

plished by placing the lamp within a copper coil through which a high-frequency current circulates. In operation the lamp is so lacking in generated heat that it may be held close to the hand without any sensation of warmth. The lamps vary in size from 1 in. in diameter to about $2^1/_2$ in. The efficiency of the new lamp, according to Elman B. Myers, the inventor, is so high that about 20 cp may be produced for each watt of energy used.

"We can develop these tubes to produce 1,000,000 cp," said Mr. Myers, "and at that brilliancy the bulk will be about 100 times as efficient as an ordinary incandescent lamp. We plan to cast television images on a theater-size screen, and expect no difficulty because we have plenty of light. The tube in use in our receiving set has been in operation 7000 hr, and we can build tubes of that size for $10." (*Electrical World*, vol. 100, no. 17, Oct. 22, 1932, p. 553, *dt*. This abstract, with the exception of one paragraph omitted, has been reproduced verbatim from the original source.)

LUBRICATION (See also Petroleum Refining: Recent Progress in Petroleum Refining—Lubricating Oils and Greases)

Extreme-Pressure Lubricants

THE Research Committee of the Society of Automotive Engineers appointed in 1931 a subcommittee to investigate the general subject of extreme-pressure lubricants. A fund was subscribed by individual company contributions and the work undertaken at the Bureau of Standards under the direction of Dr. O. C. Bridgman. The machines used were those of the General Motors, Timken, and other companies.

Results of the tests showed that comparable values were not obtained on these machines, and that the lubricants were rated in different orders by the various machines. One of the outstanding differences between the operating conditions of the machines was in the rubbing speed, which varied from 6 to 400 fpm. Other differences were in the composition of the test specimens and in the rate of heat conduction away from the oil film between the rubbing surfaces.

For the purpose of studying the effect of these differences on load-carrying capacity, machines of two diverse types were arranged for operation at various speeds and oil temperatures. Data have been obtained on representative extreme-pressure lubricants over a wide speed range and at oil temperatures ranging from 25 C to 125 C, with the result that the load-carrying capacity has been found to decrease as the temperature increases and also as the rubbing speed increases.

Because of the result of these tests, a machine has been designed that will simulate conditions encountered in gears in service and enable the measurement of load-carrying capacity over a wide speed range, with varying ratios of rubbing to rolling motion at each speed, and over a wide temperature range, with any desired combinations of metals rubbing against each other. (*S.A.E. Journal*, vol. 32, no. 1, Jan., 1933, p. 17, *e*)

MAINTENANCE ENGINEERING

Individual and Group Drives—Investment and Operating-Cost Data

AN EXTENSIVE discussion with main regard to investment and operating-cost data. When it comes to the selection of drives in some portions or departments of plants, one or another type of drive offers definite advantages from a manufacturing standpoint.

Usually, however, in parts of plants one method will give just about as good results as another, if both are planned with equal intelligence.

In the typical American manufacturing plant, which averages over a 10-year period a little less than single-shift operation at maximum capacity, with a large night shift in the busy season of boom years and short-time operation in the depths of a depression, the first cost of electrical power and mechanical-transmission items, including power-factor-correction equipment, switchboards, distribution cables, and ducts, for the individually driven plant is 80 to 95 per cent more than for corresponding group-driven plants.

The total annual costs, including fixed charges, for the same equipment listed above are about a third higher for individual than for group drive—a trifle more if the individual-drive motors average only 1 or 2 hp in size.

For the familiar "feast or famine"—the plant in which some departments work day and night while other departments have nothing to do, and which shuts down almost entirely in a depression year or in the dull season—the total annual cost will amount to about 50 per cent more for individual than for group drive. The cost will be somewhat higher, relatively, if the individual motors average only 1 or 2 hp in size.

The first cost of the whole power layout, including the mechanical power transmission and other items mentioned under the preceding example, will be from 2 to 2.2 times as great for individual as for group drive. The lower figure will hold for an industry in which 4- to 10-hp motors on the average are required on individual drives. The larger figure will apply when the motors are smaller, say, 1 to 2 hp.

In a plant that averages two shifts, except for single-shift operation in a dull season of three or four months' duration, with three shifts in boom years and one shift in depression years, the total annual costs for individual drive will be 25 per cent greater than for group drive. These costs will be a trifle more if the individual-drive motors average 1 to 2 hp in size, and a trifle less if they average 5 to 10 hp.

The initial investment in electrical power and mechanical transmission equipment, including power-factor-correction equipment, switchboards, distribution cables, and all, will be about 80 per cent greater for individual drive than for group drive, 10 per cent less if the motors are 5 to 10 hp in rating, and 10 per cent more if the average size is 1 to 2 hp. Such plants are very uncommon.

The assumptions as to performance on which these comparisons are based apply to the best-planned and operated plants of their respective types, not to average plants.

The author discusses in detail the cost of breakdowns and high repair expense of motors in the metal-working and several other industries. The increased use of automatic compensators has largely eliminated motor failures caused by ignorance in handling the manual type, and has reduced starter first and maintenance costs. Ten years ago such equipment of the best design cost as much as the motor it controlled, in the sizes most needed. Now the additional cost of automatic starters in the 30- to 50-hp sizes is roughly 20 per cent of the motor cost.

Speed reducers are more extensively used now than formerly. The increasing use of compressed cloth, rawhide, and bakelite-impregnated canvas for motor pinions has decidedly reduced the punishment on motor bearings.

There have been a number of advances that have benefited group and individual drives alike. Among such aids to the reliability of all types of drives may be mentioned routine

dipping and baking of stators, wound rotors, and direct-current armatures; ball and roller motor bearings; and improved short-center belt drives.

Motor-winding failures due to bearing troubles have been reduced by the use of ball and roller bearings. These bearings ordinarily become noisy before sufficient wear occurs to allow the rotor to rub on the stator.

Belt drives from motor to load have certain advantages, but in the past occasional difficulty was experienced with such drives when the speed ratio was considerable and the center distance short. The gravity idler, while available, was not extensively used. Today there are available on the market a number of types of ball drives that give excellent service on short centers.

The subject of interchangeable motors is discussed in some detail, this being followed by a discussion of the field for individual drive and that for group drive.

Under usual conditions group-drive motors larger than 50 hp would not be used except for groups of machines requiring so much power that only three or four could be driven by a 50-hp motor. With only three or four machines in a group, one fundamental advantage of a group drive is sacrificed—the saving in total installed motor capacity based on the fact that the maximum power demands of the individual machines do not occur simultaneously.

With so few as four machines in a group it is not safe to assume that half or more of them will not occasionally work into step. Then, if the individual loads are very fluctuating, stalling trouble may occasionally be experienced. It is in order in such cases to use a 75-hp or 100-hp motor and increase the number of machines in a group to eight, ten, or twelve. If the power consumption of the individual machines is not too variable, it may be well to consider the possibility of driving them individually.

In deciding which type of drive offers the greater advantages, departments, not entire plants, must be considered as units. A large industrial plant is really an aggregation of small factories inside one fence. One cannot lump a foundry and an assembly department, a sheet-metal department and a wood shop, a forge shop and a machine shop, in making a decision. Frequently, for best results units smaller than a department must be considered, grouping here, individually driving there, and occasionally individually driving a single machine located within an area covered by a group.

The basis of comparison is established from a consideration of comparative costs, annual operating expense, and effect of the type of drive on manufacturing conditions. This part of the article cannot be abstracted because of lack of available space.

The fundamental reasons for such differences as there may be in the first cost and operating cost of group drive and individual drive are, briefly, the higher first cost, maintenance cost, and repair cost per horsepower, as well as the poorer electrical performance and lower reliability of motors, starters, and like equipment in small sizes as compared with the larger sizes.

In the case of both individual-drive and group-drive plants the total connected motor load exceeds the maximum demand. In group drives with skilful engineering this excess is ordinarily 10 to 25 per cent under fairly favorable conditions. With individual drives the excess is, under equally skilful engineering, 200 to 250 per cent in plants where most machines work continuously at a single job, and up to 350 or 400 per cent in plants where the work approaches jobbing in variety. For reasons explained in the original article, this excess is ordinarily somewhat greater in plants where the individual machines have small average power requirements than in cases where several horsepower per machine are needed.

Reasons for the second of these two items are fundamental in all cost comparisons and are discussed in the article.

The following are said to be the three principal variables that influence the economic comparison between individual and group drive: load variations on the individual machines; the number of hours a year that it would take the plant in question working at capacity to produce its yearly output; and the average amount of power required per machine. The load variation on the individual machines is the most important and is discussed in considerable detail, with special regard to machine tools and textile plants.

As regards load capacity, it is stated that for reasons explained elsewhere most machines are overmotored at first. Group drive, however, requires less overmotoring, in addition to which group loads are more uniform, and in the case of group load, changes can be more easily corrected.

The third section of the article gives a comparison of performance and annual power cost of drives in six types of plants. The first two can be considered as abnormally stable two- and three-shift plants, designated as A and B. These two plants differ only in the average power requirements of the machines installed, and operate under conditions so favorable that they are seldom reached in American industry. In busy years or busy seasons they operate three shifts; during depression one shift is operated; and on the average over a ten-year period, they operate 4000 hr a year, which falls a trifle short of double-shift 8-hr operation. Each makes a single product all the year around, and nearly all machines operate continuously on a single piece part.

The second two plants, C and D, may be considered as representing average manufacturing industry. In normal years many departments are operated overtime, and in exceptional years there is a night shift in some originating departments, such as the foundry, forge shop, and so on. The night shift is never one-third as large as the day shift, although the departments affected operate from half to full force. During the height of a depression a much-reduced day shift works a few hours a week.

These plants do not operate all the year around on the same product. Some of the lines are year-around sellers, but other lines are seasonal to a great extent. Thus, at the height of a boom the whole plant never works to capacity on any one day. One department may be working overtime, whereas another may be working at only half-capacity. In boom periods operation has been at 90 per cent of plant capacity, but on the average over a ten-year period, including depressions, these plants run at 60 per cent of single-shift capacity. On the other hand, when any department is running at all it averages 86 per cent of capacity. This is a fair picture of an average American industrial plant. It is not the most prosperous, nor by any means the least prosperous.

Enclosed fan-cooled motor equipment is used for individual drives; principally open-type motors for group drives, as in the case of plants A and B. In tables given in the original article it is assumed that ball and roller bearings are used in the motors and shafting hangers.

In plants A and B full-voltage starting motors will be used up to 30 hp, with push-button starters. Above 30 hp, automatic compensators will be used. All motors and shafting hangers are assumed to have ball or roller bearings.

In plant B the average motor size on individual drive is approximately $7\frac{1}{2}$ hp, and in plant A, 2 hp. In plant B the average motor size on group drive is between 10 and 15 hp, and in plant A, between 30 and 35 hp.

TABLE 1 FIRST COST OF INSTALLATION OF ELECTRICAL AND MECHANICAL POWER-TRANSMISSION EQUIPMENT

FIRST COST OF INSTALLATION OF ELECTRICAL AND MECHANICAL POWER TRANSMISSION EQUIPMENT	Abnormally Stable Two-and-Three Shift Plant				Average Manufacturing Industry				Feast or Famine Industry			
	Group		Individual		Group		Individual		Group		Individual	
	A Many Small Machines	B Medium Machines	A Many Small Machines	B Medium Machines	C Many Small Machines	D Medium Machines	C Many Small Machines	D Medium Machines	E Many Small Machines	F Medium Machines	E Many Small Machines	F Medium Machines
Number of motors installed — total	270	77	5,200	1,163	270	77	5,800	1,300	247	70	6,900	1,480
Number of motors installed — "Shop standard" types and speeds	255	73	4,800	1,073	255	73	5,350	1,196	232	66	6,400	1,360
Number of motors installed — Special performance motors	15	4	150	30	15	4	175	36	15	4	200	40
Number of motors installed — "Orphan" motors bo't with machines	.....	.....	250	60	.....	.....	275	70	.....	.....	300	80
Number of spares required for shop standard motors	16	8	207	44	16	8	207	44	16	8	207	44
Number of spares required for special performance motors	4	4	50	8	4	4	55	9	4	4	60	10
Number of spares required for "Orphan" and built-in motors bought with machines	.....	.....	12	20	.....	.....	12	20	.....	.....	12	20
Cost of power factor corrective equipment to give 85% P.F. under all conditions	$3,700	b$750	$14,000	$11,000	$5,000	$4,350	$1,500	$12,500	$3,500	b$1,000	$13,650	$12,400
Cost switchboard in substation — underground ducts and manholes — mains from switchboard to cabinets and distribution cabinets	25,000	21,000	43,000	37,000	27,000	23,000	49,000	45,000	29,500	23,000	55,000	49,000
Cost of installing motors	5,500	2,850	21,300	15,000	5,500	2,850	24,000	20,000	5,000	2,600	27,000	25,000
Cost of wiring — cabinet to starter to motor	6,750	3,300	78,000	18,000	6,750	3,300	87,000	22,000	6,200	3.000	100,000	28,500
Cost of motors if all were shop standard—includes starters, pulleys, bases, couplings	44,600	30,200	395,000	181,836	44,600	30,200	435,000	203,000	40,850	27,450	486,000	228,500
Additional cost account of special performance motors	1,500	2,000	10,000	2,500	1,500	2,000	12,000	3,000	1,500	2,000	15,000	3,500
Additional cost account of orphan motors	.....	.....	15,000	3,000	.....	.....	17,500	3,500	.....	.....	20,000	4,000
Cost of spares for shop standard motors	2,894	3,472	16,000	7,447	2,894	3,472	16,000	7,447	2,894	3,472	16,000	7,447
Cost of spares for special purpose motors	700	1,500	4,000	2,000	700	1,500	4,500	2,200	700	1,500	5,000	2,400
Cost of spares for orphan and built-in motors	.....	.....	2,000	5,000	.....	.....	2,000	5,000	.....	.....	2,000	5,000
Total electrical costs	90,644	65,072	598,300	282,783	93,944	70,872	648,500	323,647	90,144	64,022	739,650	365,747
Cost of mechanical transmission equipment a	280,000	133,000	106,000	53,000	295,000	140,000	111,588	53,000	305,000	148,000	117,000	60,000
Grand total	$370,644	$198,072	$704,300	$335,783	$388,944	$210,672	$760,088	$376,647	$395,144	$212,022	$856,650	$425,747

a In groupe this includes hanger supports, hangers, shafting, countershafts, pulleys (except motor pulleys) belts, and guards.
For individual drives it includes belts, pivoted motor bases, gravity idlers, chain drives, chain enclosures and belt guards, gear drives (couplings are included with motor pulleys under motors).
b No separate synchronous condenser required; this is the additional cost of 80 per cent power factor synchronous motors on compressors as compared with 100 per cent power factor motors.

The third pair of plants, E and F, are representative of "feast or famine" industries. Such operation is characteristic of seasonal industries like those of vegetable and fish canning, building supplies, shoes, ladies' hats, etc. Similarly, some industries must be included such as railroad-car manufacturing that operate on huge contracts of which no great number are let in any one year, and very few in depression years. Such plants may have all the contracts that they can handle for steel freight cars, and nothing to do in the passenger-coach or motor-bus-body departments, or vice versa.

A comparison of performance and annual cost of drives in the six types of industrial plants referred to is given in the original article.

Fig. 7 of the original article shows efficiency curves recently determined under the direction of Professor Sawdon at Cornell University for several drives suited to motors around 15 to 30 hp capacity. There are included short belt drives with gravity idler, pivoted motor base, and rubber V-belt drives, each with bottom-pull and top-pull installation, and presumably operating under rather favorable conditions; at least, no vertical drives are included.

The most interesting conclusion to be drawn from these curves and the accompanying data on creep and slip is the fact that, contrary to the usual assumption, the slip loss is not nearly the total loss in the drive.

The fourth section of the article is devoted to a consideration of first cost of group and individual drives, and gives tables of actual cost data for six characteristic types of industrial plants. These include some details as to the motor installation costs, wiring costs, and motor-starter costs. The most difficult item to estimate both for group drive and individual drive is the cost of mechanical transmission. The difficulty lies in deciding upon what are the "average" conditions. From this point of view Table 1 is of particular interest, as it is based upon detailed cost data from actual operations which cover 96 machines. The final section gives total annual comparative cost data for six characteristic types of industrial plants. The conclusions are interesting, but cannot be abstracted here because of lack of space. (Robert Drake, Electrical and Mechanical Engineer, Chicago, Ill., in *Maintenance Engineering*, vol. 90, nos. 6, 7, 8, 9, and 10, June, July, Aug., Sept., Oct., 1932, pp. 237–242, 287–292, 317–321, 352–356, 386–391, *dcA*)

METALLURGY (See Engineering Materials: A Method of Increasing the Wear Resistance of Cast Iron)

PETROLEUM REFINING

Recent Progress in Petroleum Refining—Lubricating Oils and Greases

IN THE lubricating-oil field where sulphuric acid has held sway for treating, further work is being done. Sulphur dioxide extraction methods have proved beneficial, and late development in this process includes the use of another solvent in combination with sulphur dioxide which has proved valuable with certain types of oils. One company successfully uses benzol in solvent extraction in treating lubricants. Many solvents are being employed, among them being propane, acetone, etc. Much of the work is directed toward simpler methods of wax removal, including the press and centrifuge, or both. New processes in this field are to be announced which will modify present practice both in wax removal and in chemical treatment. In the meantime new processes are available for the concentration of sulphuric acid and for its manufacture in the refinery yard, and in this latter, using some of the refiner's favorite curse—hydrogen sulphide. These developments will contribute to lowered acid costs and to less acid purchases by the industry, at the same time aiding in the solution of the acid-sludge-disposal problem.

In the manufacture of lubricants and greases, other developments are under way in addition to those mentioned above. The use of flue gases for blowing down or drying filters is being adopted in connection with the modern continuous vacuum filter plants and the flexible pressure filter plants. These are improvements in wax sweating. Experience and research have given improved controlled operation of the multiple-hearth furnaces used in roasting fullers' earth.

The grease-plant department of the refinery has been adopting pressure saponification, adding the pressure kettles to the plant formerly using only open kettles, and speeding up the output of finished greases, cutting down the cost per pound. The process now demands the presence of grease filters for removal of rust, lime, specks, etc. Lead-soap greases were developed for extreme-pressure lubricants. They preceded a similar investigation in the lubrication field where metallic oxides were added to oils when claims of workers pointed to a deposit of the added metal on working parts of machines lubricated with them. In the grease field a new development points to the possible supplanting of compounded extreme-pressure lubricants by a product derived from paraffin-base petroleum by distillation. In this field much advance has been made. Essentially the processing steps are similar to those of years gone by, excepting for pressure saponification and different means of heating kettles. The principal factor in securing economy is that of design of the grease plant.

Having listened at a conference through all the discussion of possibilities, processes, systems, developments, in each of the major departments of the complete refinery to be rebuilt, it is necessary to admit that the conferees did not thoroughly cover the ground and that they omitted discussion of a number of highly interesting developments in certain departments that would have given additional value to this report. Needless to state, however (for such is always the case), part of their discussion was censored at the time or deleted from the written report.

One thing is clear, however, and that is that technical advancement is fast. The difficulties involved in the proper selection of refining facilities are numerous. The problem becomes all the more intricate through knowledge of the fact that what is selected and constructed today, will in all probability be obsolete five or six years hence, for this industry has definitely abandoned its old-fashioned "hammer and tongs" practices. (Geo. Reid in *Refiner*, vol. 11, no. 10, October, 1932, pp. 528–530, 1 fig., *dg*)

POWER-PLANT ENGINEERING (See also Engineering Materials: Refractory Service, With Particular Reference to Boiler Furnaces)

Operating Results With a 1350-Lb Plant

THIS article describes two and a half years' experience of the operation of the Gilbert Station, Holland, N. J. This was formerly designed for operation at 400 lb, and the jump from that pressure to 1350 lb, although not involving any considerable increase in steam temperature, introduced many important factors which required careful redesign. In this connection it should be noted that the Gilbert Station is not a stand-by plant, although the load fluctuates considerably. The design of the plant is such that although capable of continuously putting out about 55,000 kw, it should operate well with two boilers in service down to an output of 30,000 kw, at which output one boiler is cut out. Below this, down to as low as 12,000 kw, one boiler unit can operate the plant economically at less than one-quarter of the plant rating.

The blading of the high-pressure unit has given no trouble whatsoever. The replacement of cast iron by nitralloy in the governor bushings has proved quite satisfactory, and the troubles which at times were quite serious have been completely cured.

There was, however, continued trouble from the governor not acting quickly enough when the load was suddenly thrown off by lightning, causing overspeeding of the turbine. The final method adopted for curing this difficulty had to be applied entirely outside of the plant, and its final rectification consisted in changing or readjusting all relays on the transmission system as the remedy for inherent system instability. Since this was done the governor has been relieved, and parts of the system affected by lightning have cut themselves out automatically, without causing sudden cutting off of the entire plant load. Obviously this particular difficulty was not caused by the 1300-lb steam pressure, though the effects on the plant operation were aggravated by it.

There was one unforeseen difficulty involving the design of the economizer connections which had rather far-reaching results. Reference has been made to the greater length of time required for warming up the boiler units of this plant, as compared with boilers operating at the familiar lower pressures. As the economizer receives gases from the boiler outlet which are relatively hotter than is the case with plants designed for lower operating pressures, the water it contained was very quickly heated up during the period of bringing the boiler up to pressure, during which period there is no circulation between economizer and boiler, as no appreciable amount of steam which requires water replacement is delivered from the boiler.

Hence the contents of the economizer were very quickly converted to steam and had to be replaced by water, which had the effect of causing rapid temperature changes in the economizer, making it leak. This leakage continued after the boiler got into continuous operation and overworked the evaporator, ultimately causing higher concentration of solids in the boiler than is normal, which, in turn, caused deposits of solid matter on the turbine blading.

This whole chain of difficulties was corrected by the simple expedient of installing a connection from the lower portion of the boiler direct to the bottom of the economizer, which thus created a circulation in the economizer during the warming-up period. This circulation kept the economizer full of water, stopped the leakage between the economizer tubes and headers, relieved the evaporator of its extra duty, introduced water of normal concentration into the boiler, and solved the whole problem.

As regards the gas reheater which is built into each boiler unit and reheats the steam exhausted from the high-pressure turbine on its way to the low-pressure turbine, it is stated that when the plant was started the reheat temperature was found to be entirely too high, and the remedy employed was to remove reheat surface from both boiler units. This cured the trouble so far as the heat problem was concerned, but some months afterward the reheater had to undergo repairs which required the replacement of three tubes. Steam passes through these tubes at about 400 lb pressure and one of the tubes had a minute pinhole, probably an original defect, which was so small that the steam which escaped from it did not make noise enough to be heard, and it was not until this escaping steam had eroded the walls of two adjacent tubes sufficiently that the operating staff discovered what was wrong. Since the replacement of these three tubes no difficulty has been experienced with the gas reheater.

The use of the steam reheater has been discontinued because the gas heater has proved to be ample for all requirements, except at very light loads.

The secondary boiler-feed pumps have given some trouble, but did not apparently cause any outages.

The outage is thus in the proportion of 28.6 per cent for high-pressure repairs and 71.4 per cent for low-pressure repairs; in other words, the low-pressure repairs called for about two and one-half times the outage taken up by high-pressure re-

pairs. Some of the shorter week-end shutdowns, lasting from one to three days, were ordered by the load dispatcher for system reasons. One of the boilers was sometimes shut down over a week-end because there was not load enough to warrant operating it. (J. A. Powell and G. T. Dempsey in *Electrical World*, vol. 100, no. 22, Nov. 26, 1932, pp. 716–720, 3 figs., *d*)

RAILROAD ENGINEERING

Streamlined High-Speed Car of the German National Railroad Company

SHORT experimental runs at speeds of the order of 200 km (125 miles) an hour were carried out in 1901 to 1903 on the short military railroad between Marienfeld and Zossen, but these tests did not lead to commercial developments. Among the reasons for this partial failure may be mentioned first and foremost the fact that engineering, both railroad and aerodynamic, had not then arrived at a stage that would permit commercial utilization of such enormous speeds.

Among other things, the great weight of the rolling stock and the excessive power consumption in overcoming air resistance were important factors. Furthermore, the Zossen experimental line used electric traction, and the cost of such an installation on any large scale would be prohibitive under present economic conditions in Germany. Finally, thirty years ago there was no special reason why speeds of the order of 120 mph should be resorted to, or at least such was the impression at the time. The situation has changed completely today. Automobile competition makes it imperative to run railroad trains at much higher speeds than formerly. The Diesel engine and electric drive now provide a means for operating trains at high speeds without the enormous investment that electrification of a line would require, and further, modern developments in metallurgy have provided light and strong materials and internal-combustion engines of low weight. It is because of these considerations that the German National Railroad Company decided to install a high-speed unit for operation on the line between Berlin and Hamburg.

As regards the selection of the top limit of speed, this was decided on the basis of the requirements that the car must be capable of stopping within a predetermined distance from a signal, and of being operated in such a manner as not to disrupt existing traffic on the line. A careful study of the problem showed that a speed of 150 km (94 miles) per hr would be satisfactory.

Apart from data collected in somewhat crude experiments on the Zossen line, there was no information available as to resistance of railway trains operating at such velocities. A determination of the air resistance, which constitutes the largest share of the total resistance, was carried out by means of model tests in a wind tunnel. All the other resistances were calculated in the usual manner.

Because of its safety from the point of view of fire and use of comparatively cheap fuels, the Diesel engine was selected, preference being given to the 410-hp Maybach motor. Previous calculation had shown that two such motors would permit operation at 150 km (94 miles) per hr of a unit consisting of two cars coupled together and capable of carrying 100 passengers. The design called for two end trucks with a common Jakobs central truck, the matter of air resistance being minimized by giving the car a proper shape. The transmission from the crankshafts of the motor to the driving shafts was to be effected electrically. In a car built previously for the National Railroad authorities in Frankfort-on-the-Main, a 410-hp Maybach Diesel motor had been installed with its generator on a car truck. The same construction was adopted here. It has the advantage that the vibrations and oscillations of the Diesel engine are kept away from the car frame proper, and that the heavy weight of the machinery rests exclusively on the trucks, while the frame of the car can be made as light as possible. In this case, therefore, the two end trucks each carry a 410-hp Maybach Diesel engine with its generator, while the central truck carries two independent motors for driving its two axles. The Gebus system was used in the electrical installation. The total installation weighs empty 74,400 kg (163,700 lb) to which must be added 3000 kg (6600 lb) of fuel oil and water, giving a total of 77,400 kg (170,300 lb) of which each of the end trucks carries 34,880 kg (76,700 lb) including its own weight of 13,080 kg (28,800 lb), and the central truck carries 27,640 kg (60,800 lb) including its own weight of 13,560 kg (29,800 lb). Fig. 4 shows a plan and elevation of the car. (See also half-tone illustrations on page 157.)

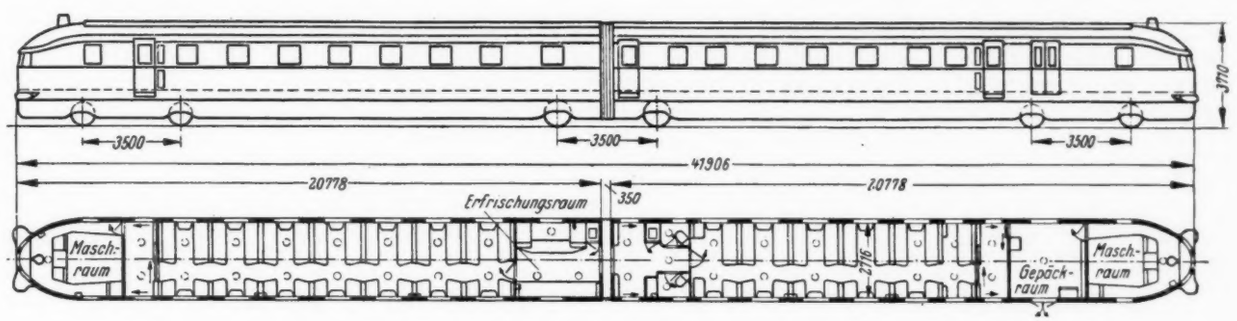


FIG. 4 SIX-AXLE HIGH-SPEED DIESEL-ELECTRIC-DRIVEN CAR USED ON THE BERLIN-HAMBURG LINE
(All dimensions in millimeters. *Masch.-raum* = engine room; *Gepack-raum* = baggage compartment; *Erfrischungsraum* = dining room.)

Every effort has been made to produce a design offering as little air resistance as possible. The principle of the drop shape such as is used in the design of lighter-than-air craft could not be introduced here because of the length of the car and the necessity of operating at equal efficiency in either direction. The design was determined on the basis of model tests carried out in the wind tunnel of the Zeppelin Airship Company. As worked out, the ends of the cars are sharply rounded, while the roof slopes down at both ends.

In order to reduce the air turbulence the space under the car was covered over by sheet-iron aprons extending very low, while the heated air from the coolers located under the car floor was permitted to escape through louvres.

The Maybach engine is shown in Fig. 5, and details thereof are given in the caption. Mechanical injection is used, which has

the advantage that it permits employing the conventional compression chamber such as has been found to be thoroughly satisfactory in withstanding thermal and other stresses. Moreover good combustion takes place at all speeds and loads, with a comparatively high volumetric efficiency. Each cylinder is provided with its own injection pump and an automatic injection valve. The pumps for each row of cylinders are assembled in a single block and are driven from the flywheel side of the Diesel engine. In the drive of the injection pump is built an injection regulator which automatically adjusts the injection timing dependent on speed variation. This permits obtaining a very "soft" run of the engine at all speeds. Regulation is effected by means of an oil-pressure regulator (illustrated in the original article) which controls the output of the fuel pump through an oil-pressure servo-motor piston. This servo-motor piston applies oil pressure on only one side and therefore effects an opening of the fuel pump working against a powerful spring built into the regulator and tending to produce a closing movement of the pump.

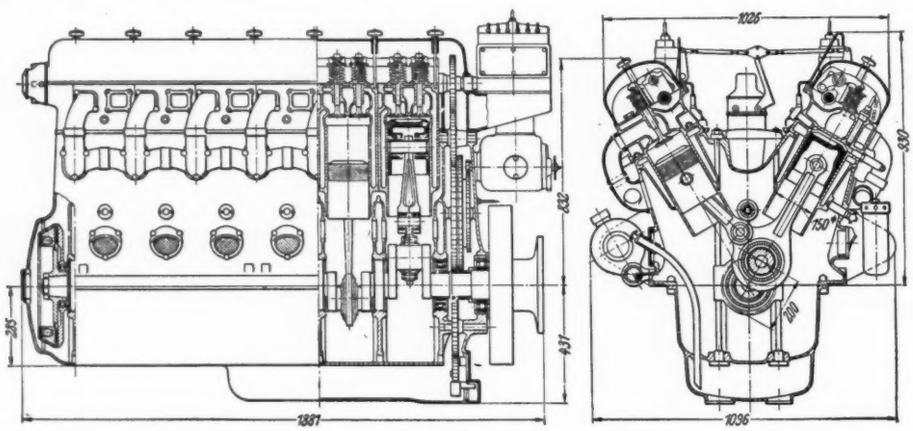


FIG. 5 410-HP MAYBACH DIESEL ENGINE
(All dimensions in millimeters.)

Cruising output	410 hp	Weight of engine per hp	4.7 kg = 10.36 lb
Output for 1 hr	430 hp	Fuel consumption at most favorable load	180 g = 0.397 lb per hp-hr
Speed	1400 rpm	Length of engine	1865 mm = 73.4 in.
Number of cylinders	12	Height of engine above center line of crankshaft	915 mm = 36.0 in.
Cylinder diam	150 mm = 5.91 in.		
Stroke	200 mm = 7.87 in.		
Weight of engine	2030 kg = 4476 lb		

Since the servo-motor piston is actuated from the lubricating-oil circuit, the Diesel engine automatically stops under the action of the spring closing admission to the pump as soon as the lubricating-oil pressure, because of some trouble, falls below a certain limit, and this makes it unnecessary to provide a separate control of lubrication. Moreover the regulator prevents the engine from exceeding a permissible maximum speed. The motor is started electrically by means of a storage battery feeding into the main generator, which then operates as a motor.

In order to obtain an effective cooling of the lubricating oil and at the same time keep the crankcase thoroughly ventilated, the motor takes in all of the fresh air of combustion by suction through the crankcase. As the roller bearings used throughout produce only a slight amount of heat, no special oil cooling is required. Furthermore, all possibility of oil and oil vapor penetrating into the engine room is eliminated.

Among the many interesting details of this unit may be mentioned preheating of cooling water, which is intended to prevent its freezing in cold weather. This is done by means of an electric heater consuming as much as 3260 watts. A circulating pump drives the heated water through the entire cooling-water circuit.

This is, of course, done only when the engine is not running, and the current may be supplied by a connection from an outside source. Details of construction and of the electrical part of the equipment, as well as of various safety measures, are given in the original article. (Friedrich Fuchs and Max Breuer in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 77, no. 3, Jan. 21, 1933, pp. 57–68, 28 figs., *dA*)

THERMODYNAMICS

Heat Transmission From Metal Surfaces to Boiling Liquids

THE data available in the literature relating to the direct measurement of the liquid-film coefficient for heat transmission between metal surfaces and boiling liquids are said to be very meager. In previous work, practically all of the information was confined to the overall heat-transfer coefficient based on apparent temperature differences between condensing steam and boiling liquid. These overall coefficients include the condensing-steam film, pipe-wall scale, and boiling-liquid film, and it is difficult to determine from the overall coefficient the individual coefficient from the boiling-liquid film. These difficulties were avoided in the present study by measuring directly the heat transfer from the electrically heated clean brass surface to the boiling liquid. The most important variable affecting the correlation of boiling-liquid-film coefficients is the rate of circulation of the liquid past the heated surface. The experimental procedure by which the data were determined and the correlation of the data are set forth in the original article, where also equations have been derived for the proper correlation between the variables. These equations are not claimed to have general applicability and are chiefly dimensionless. A sample calculation is given. (D. S. Cryder and E. R. Gilliland, Pa. State College, State College, Pa., in *Industrial and Engineering Chemistry*, vol. 24, no. 12, Dec., 1932, pp. 1382–1387, 7 figs., *eA*)

A New Equation for the Relation Between Temperature and Pressure of Saturated Steam

PARTICULARS regarding an equation of this nature, developed by Sugao Sugawara, of the Kyoto, Japan, Imperial University, and based on values given in the skeleton table published by the International Steam Tables Conference, will be found in an abstract printed on page 176 of this issue.

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer.

SYNOPSES OF A.S.M.E. PAPERS

(Available Upon Request)

COPIES of the papers and reports abstracted on this and the following pages may be obtained, until the supply is exhausted, by addressing the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y. Papers not numbered are available only in the form of reproductions of typewritten text.

AERONAUTICAL ENGINEERING

Parachutes for Airway Passengers

THE paper discusses the types of parachutes that have been designed for transport airplanes. The public demands safety to the maximum extent, although apparently not knowing that it is not the custom to have parachute equipment aboard the usual transport airplanes. The difficulties of installing and operating safety devices are outlined, and the types at present available are discussed. These include equipment for letting down the entire aircraft or a detachable part of the fuselage, and also the personal type depending upon the weight of the user or on droppable seats or those manually operated. (Paper by Guy M. Ball.)

Effect of Airplane Impact on Airport Surfaces

THERE are four forces caused by airplanes that are destructive to airport surfaces: impact, suction, shear, and abrasion. This paper treats of impact, which may or may not be the most destructive of the four forces, depending usually on the character of the landing gear of the airplane and the type of airport surfacing. The author's conclusions are based on studies and surveys made since 1929 by a joint committee of the Aeronautics Branch of the Department of Commerce, the American Engineering Council, and the American Road Builders' Association. The destructive effects of airplane impacts on airport surfaces are negligible when these surfaces are designed and constructed in accordance with the best highway practice. (Paper by C. N. Conner.)

Aircraft-Engine Steels

IN MAKING steels for aircraft-engine use, great care is exercised in all operations. The majority are microscopically inspected and micro-etched. Charts of steels at 100 magnifications have been made up and are used as standards. The paper discusses the available steels for aircraft-engine use and gives the analyses and the physical characteristics of some of them. (Paper by N. L. Deuble.)

The Ideal Transport Airplane

UPON making air transportation pay depends the future of air transport. An important phase of this problem is the selection of flying equipment. To secure the best combination of engine, airplane, propeller, and equipment for carrying passengers, mail, and express safely, economically, and on schedule is a difficult task. The ideal transport airplane is defined as one capable of being operated at a profit. The author discusses the essential elements in the design of an ideal transport airplane as suitability, comfort of passengers, safety, economy of operation, and performance. Paper by E. W. Dichman.)

Cost of Air-Line Operation

EVERY accepted type of heavier-than-air aircraft is being used on the almost 27,000 miles of routes in the air-mail system. The aggregate operating expense of these carriers amounts to about $2,000,000 a month. The operators and the Government, working together, are obtaining control of the trend of operating expense and increased efficiency and improved methods, and are showing definite decreases in some of the most important items of operating expense. Air-transport service has steadily gone forward during the current difficult business situation, has made definite gains in passengers and pay load carried, and is on its way toward becoming a profit-making, passenger-, mail-, and express-carrying industry, independent of outside financial subsidy or aid. (Paper by W. I. Glover.)

Evolution of Metal Construction

FOR the last ten years the trend in airplane construction has been toward metal design, but in the last two years development has definitely established that all-metal construction will be the probable future method. An extensive change has taken place in design practices, which must be reflected in manufacturing processes. The author presents the subject by tracing the history of the production of the Boeing pursuit planes, because the construction of military aircraft requires the highest quality of workmanship, combined with the most modern methods of manufacture and design. As to the future, little more can be accomplished with the metals at present available. Large-quantity production is as yet untouched, and with mass manufacture the prices of light, high-strength alloys may be brought down, and newer materials, which are at present only laboratory developments, may be produced. (Paper by G. W. Carr.)

Aeronautical Research in Canada

CANADA offers a great field for aerial transportation, owing to the latter's flexibility, over areas where rail transportation is impracticable. Laboratories and wind tunnels for the research of aeronautic problems have been in operation for quite a few years, but recently there has been set up by the National Research Council of Canada a wind tunnel at Ottawa of the open-air-stream, closed-return type. A number of problems have already been investigated. The wind tunnel is available for testing full-scale aircraft components and attachments, and the model-testing basin will be employed on the design and test work for surface craft, under-

water structures, and machine screws. (Paper by J. J. Green, G. J. Klein, and K. F. Tupper.)

Recent Advances in Weather Service in Relation to Aerial Navigation

THE intensive and specialized service for aeronautics in the United States is described. Frequent individual reports tell of the weather now, short-range forecasts cover the individual flights or announce the weather that is soon to be, and the longer period forecasts indicate the likelihood of successful flying several hours ahead. Now that the observational service has been placed on a systematic and permanent basis, a comprehensive program has been adopted for the compilation and summarization of all data obtained. Investigations are in progress or in prospect for improved methods of obtaining data and making them quickly available. (Paper by W. R. Gregg.)

Regularity and Safety in Flight

COMMERCIAL air transport is headed for wide patronage and success as soon as schedules can be maintained with regularity paralleling those of the railroads. Present airplanes are safe and reliable mechanically. Flight through or around any weather and navigation to the destination are now possible with equipment already developed and proved. Landing is now possible in all but the worst weather conditions, and development is now well under way which will solve this problem. (Paper by E. G. Haven.)

The Relation of Design to Economy in Transport Planes

AVIATION as a science, and to a certain extent as an industry, will continue to prosper under the urge of military development, but to take its proper place in the field of transportation, it requires more than the impetus of sensational achievements. Transoceanic flights, polar conquests, speed records, and good-will tours have quickened and left vivid memories of skill and fortitude and of superb mechanical performance. The cost of flying, however, has prevented the vast majority of aviation enthusiasts from owning and flying their own ships for pleasure and recreation, so this portion of the industry is rather restricted to the patronage of the well-to-do sportsmen. The real and permanent expansion of any industry is very much a function of the volume of patronage which it enjoys. When specifically applied to aviation, it leads to the conclusion that the transport division must be wholeheartedly fostered with a vision of ultimately carrying a large portion of the traveling public by air. (Paper by R. G. Lockwood.)

Sonic Marker Beacon for Fog Aviation

MEANS of utilizing sound signals as aids to the landing of aircraft in fog are not new, several suggestions having been made. The paper describes a sonic boundary-marking system that may also be used as a marker beacon in many other applications. In a typical installation on an airport 2000 ft sq the sonic boundary markers send out different code signals so that the aviator will know his relative position above the field and in relation to its area by the commingling of the fan-shaped beams of sound or their distinctness. By making several trips through the sound field above the airport, he determines its extent and its boundary positions, and in consequence is enabled to make a blind landing. (Paper by C. W. Rice.)

Monocoque Construction in Theory and Practice

THREE and a half years have elapsed in this country since the first real attempts were made to design and build all-metal monocoque airplane structures. From early designs there have gradually been evolved the three types of stressed-skin construction—full-monocoque, semi-monocoque, and reenforced-shell. Little had been done to metalize wing structures, but the fuselage and its covering have been constructed of aluminum alloy, and lately of stainless steel. Since spot welding has come into prominence, along with stainless steel, a decided advantage is presented. If the cost of airplane construction is to be reduced and the way made clear for quantity production, there must be a change from the present form of monocoque construction. The author, from a long experience, presents some suggestions. (Paper by R. L. Schleicher.)

Protecting the Airplane From Ice

CONDITIONS of weather often interfere with airplane flying schedules, particularly when ice forms on the exposed surfaces. Protection for the stationary members consists of rubber overshoes that are cemented along the leading edge of the wing. These are inflated and deflated once a minute by an air pump driven from the engine. This action breaks the ice off in small pieces, and the air stream carries them away, so that by continuously freeing the leading edge the whole surface is protected. The propeller hub is encased in a spinner whose outer surface is coated with rubber. An oil of low freezing point is applied and is absorbed by the rubber to form a gelatinous surface to which ice has low adhesion. (Paper by W. L. Smith.)

Standardizing Location and Direction of Travel of Stabilizer Control in the Cockpit

THE location of the stabilizer control, the author points out, should be standardized. Placed variously to one side or the other, on the roof or the floor or the instrument board, or even to the rear of the pilot, the method of control and direction of travel are confusing. If the throttle and the stabilizer control were placed adjacent, preferably on the left of the pilot, the right hand could remain on the flying controls, while the left hand could be used on the throttle and the stabilizer control. (Paper by C. C. Swartz.)

Wind Loads on Airship Hangars

WIND loads on airship hangars and the possibility of failure through improper design are covered by the author. The following recommendations are made: That the entire question of outward pressures on airship hangars and similar structures be considered by designers; that the covering material on roof, walls, and doors be secured sufficiently to resist the highest velocity wind; that structural members be so designed that the tension members of the truss can safely resist any reversal of stress; and that in all cases at least one model of the structure be tested in a wind tunnel. (Paper by H. M. Sylvester.)

The Aircraft Sextant

WITH all the scientific aids to airplane flight, a weak point remains in the development of the sextant, present types being difficult to use and also inaccurate. Modern aircraft sextants are based on the principle of the spirit level for establishing the horizontal. The artificial horizon has been given the benefit of intensive work. The bubble sextant gives

the nearest approach to perfection, except that the bubble cannot distinguish between gravity and acceleration. Pendulous sextants are identical in principle with the bubble sextant, but are less accurate. Other solutions are the gyroscopic sextant or the discovery of some new principle. The airplanes of the future will, on long flights, have relief pilots who should take observations every few minutes to check the position. (Paper by P. V. H. Weems.)

Report of Special Committee on Wage Incentives

THIS is a preliminary report of the A.S.M.E. Aeronautic Division's special committee on wage incentives in the aircraft manufacturing industry, presented at the Buffalo aeronautic meeting, June 6–8, 1932. In it the statement is made that airplanes to a value of about $85,000,000, produced in the years 1929 to 1931, cost about one-third of that amount for wages, at a certain rate per hour. Three to five plants had partial systems of bonus payment, but wages paid under these plans were insignificant when compared to the total wages paid. Questionnaires were sent to 78 manufacturers of aircraft in the United States; and the present report sums up the replies that were received.

A Comparative Study of Welded and Riveted Fuselages

THIS is a study instituted by the Aeronautical Society of Philadelphia. It holds that a surprising lack of actual fuselage joints and an inclination to test member combinations that are incomplete and never found in an airplane are probably responsible for the fact that available data are of an academic nature. More definite conclusions must await considerable testing of complete fuselages or portions thereof differing in construction. Although a single joint or bay may be taken as a measure of merit, such a procedure neglects the fact that every fuselage varies considerably from engine ring to tail post, and that the best methods of construction at the wing hinges may be the most inefficient in the tail, or vice versa. The advent of the metal monocoque and stainless steel may inspire such testing. The fact that existing facilities for manufacture and repair do and must continue to influence the fabrication methods of the industry must be realized.

HYDRAULICS

Turbulence in Centrifugal Pumps

IN THIS paper the author discusses whirlpool or vortex energy in centrifugal pumps, the harnessing of this energy for useful work, and the effect of different kinds of inequalities in vortices. He deals respectively with (1) inequalities in the forced vortex of an impeller in a simple centrifugal pump; (2) waste energy in a centrifugal-pump impeller; and (3) the synchronization of parallel vortices in mixed-flow impellers. The treatment of the subject is prefaced by a brief description of a method of calculating head losses in river bends when the radius of curvature is known, the results obtained with which led to the development of the pump study presented. (Paper No. HYD-54-4, by J. W. Macmeeken.)

Leakage Loss and Axial Thrust in Centrifugal Pumps

THE paper reports on experiments performed by the author at the Hydraulic Laboratory of the University of California with equipment furnished by the Byron Jackson Company, Berkeley, Calif. Factors governing leakage loss and means to reduce leakage loss were studied. With a special pump, leakage was measured under actual operating conditions, using wearing rings of various types, width, and clearances. Tests were performed at four speeds and different heads. The results are presented in the form of curves, the coefficients of discharge through the clearances being plotted as ordinates against pressures at the wearing ring as abscissas. To facilitate the calculation of the pressure at the wearing ring the pressure distribution in the pump case was studied and an approximate formula was developed. The axial thrust in single- and multi-stage pumps was measured with a specially designed thrust bearing which indicated the thrust directly in pounds under actual operating conditions. New sources of thrust were established—those caused by unequal pressures on the impeller shrouds from the inside due to various causes, the most important of which are an uneven radial velocity distribution and cavitation. In multi-stage pumps, with impellers mounted back to back, generally considered balanced on account of symmetry, it was discovered that there is considerable axial thrust produced by unequal pressures in adjacent stages acting upon the shaft shoulders and impeller hubs extending through the walls of the adjacent stages. Means to eliminate this thrust were found. (Paper No. HYD-54-5, by A. J. Stepanoff.)

Hydraulic Jump in Sloping and Horizontal Flumes

THE formulas presented in this paper were developed on a rational basis by the author in an attempt to solve for the tail-water depth of the hydraulic jump when it is produced in either sloping or horizontal flumes. A recent study of the mathematical analysis of this phenomenon has brought to light certain interesting relationships which are discussed in the paper. The conclusion drawn from this investigation is that Prof. W. C. Unwin's momentum formula is really a special case of a more general formula which can be used to include jumps produced in both sloping as well as horizontal flumes. Data from a previous paper by the author entitled, "Computation of the Tail-Water Depth of the Hydraulic Jump in Sloping Flumes" are used to substantiate the theoretical conclusions reached in the present one. (Paper No. HYD-54-6, by R. W. Ellms.)

Hydraulic Practice in Europe

THE title describes in general the nature of this paper, but the author has confined the discussion to such features of European practice as are different from those in America. Various types of reaction turbines and draft tubes are illustrated, and also some two-nozzle Pelton wheels and one vertical four-nozzle machine. Types of valves, gates, and weirs peculiar to the Continent are discussed, and also some features of pumped-storage plants, with the special design of pump that is peculiar to them. (Paper No. HYD-54-7, by R. W. Angus.)

Investigation of the Flow Conditions in a Centrifugal Pump

THIS paper gives an account of an investigation recently carried out in the laboratory of the Technical University of Munich, into the flow conditions in the impeller of a centrifugal pump, the results of which may be summarized briefly as follows: (1) Practically all flow conditions for an actual fluid are fundamentally different from those theoretically derived for an ideal frictionless fluid. (2) The dead-water zones which form on the low-pressure sides of the blades undoubtedly cause a reduction in the angle at which the fluid leaves the

blades from the actual blade angle. (3) The actual velocity distribution along circles concentric with the axis of rotation of the impeller is not the same as the supposed distribution computed on the basis that the fluid passages are completely filled with active flow. (4) The relative velocity along the high-pressure side of the blade should theoretically approach zero for relatively small reductions in the discharge below normal and with the fluid passages completely filled with active flow. Actually this velocity is greater than the theoretical value, and reverse flow along the pressure side of the blade does not take place even at small discharges. (5) In addition to (4), it was definitely proved that the flow at very small discharges is no longer stable. (6) The entrance flow may be assumed to be radial for all practical operating conditions. (7) The increase in the meridional velocity over the ordinary computed value alters the shape of the exit triangle considerably, which is of special importance in designing the guide-vane entrance angle. (Paper No. HYD-54-8, by K. Fischer and D. Thoma.)

STEAM POWER

The Balanced Natural-Flow Condenser

THE balanced natural-flow condenser, while believed to be an important contribution to the art of condenser engineering, discloses nothing of a radical nature in its design. As in present practice, it comprises a shell, or condensing chamber, having the various essential flanged openings and enclosing a tube bundle.

It embodies four features of note. The first is the parallel arrangement of tubes, thus removing the throttling effect, or area reduction, in the path of natural vapor flow, characteristic of the converging-lane principle.

The second feature is the balanced pattern of bi-pass holes in the tube supports, between the similarly balanced vertical lines of tubes. Whether by the use of tube supports or by other media, the intent is to remove the sectionalizing effect of tube supports and provide means to approach the full benefits accruing to parallel-tube arrangement; that is, balanced natural vapor flow throughout the extent of the condensing chamber and in increased quantities toward the region of lowest-temperature surface.

The third feature is the location of the air and non-condensable-vapor header with relation to the tube bundle in general, and the final cooling tubes in particular. Extending the full width of the tube bundle, not only does it assist natural flow in balanced relation throughout the width of the tube bundle, but due to its location in the region of lowest temperature surface and lowest pressure, the only natural vapor exit terminal, it insures temperature reduction of exhaust gases to the minimum consistent with a given water temperature.

The fourth feature is the location of condensate drain plates in relation to the tube bundle in general and the final cooling tubes and non-condensable-vapor header in particular. These, too, extend the full width of the tube bundle so as to preserve the balanced natural-flow relation already provided for, and to remove the resistance to such flow that would result from an otherwise heavy rain of condensate over the final cooling tubes. Located as they are, these plates offer negligible resistance to natural flow in performing their important function of collecting condensate and providing for its drainage through end ports to the shell wall and center-lane plates.

These four fundamental features combine to eliminate the many directional changes, turbulence, and eddies affecting steam flow, and common to most of the present-day types of condensers, and are believed to provide many requirements and advantages of a practical approach to ideal condensing apparatus in so far as it is physically possible to obtain them with surface of substantial amount and, of necessity, extending in a third dimension.

And in further consideration of the fact that this arrangement affords maximum dissipation of high velocity and adverse directional effect of exhaust steam within the upper, or lesser, portion of the condensing surface, the condenser can be said to consist virtually of a number of narrow duplicate condensers, arranged for parallel operation, but without separating walls, enclosed within a common condensing chamber and so arranged as to promote natural vapor flow from a common inlet terminal, or region of highest pressure, to an exit terminal common to all condensing elements in the region of lowest potential pressure. Hence the name, balanced natural-flow surface condenser.

Of no less importance than the demands of the power-generating industry for improved condenser efficiency, is the demand for an acceptable method of testing condensers, not alone for the purpose of determining performance, but in order to obtain rational results. The problem of design is an important factor in the process of testing, and apparently one of approaching the ideal, with the result that the closer the approach thereto the fewer will be the remaining intangible factors to introduce errors.

The balanced natural-flow condenser is offered as a contribution in the direction of that ideal, and is presented not alone for the purpose of improving condenser efficiency, but to render the collection of rational test data a feasible procedure. Not only has the vapor circuit been so treated as to promote tranquil natural flow in balanced relation between the maximum of duplicate elements arranged for parallel operation, but the hydraulic circuit has been similarly treated with a view to approaching equal flow of water through all tubes on any horizontal line, and toward maintaining water at a constant density over the entire width of the water box at any horizontal line of tubes.

These features combine with the balanced tube arrangement to afford a practical approach to the ideal condition of water-filled tubes throughout the extent of the tube bundle, constant velocity at least through tubes on any horizontal line, water of constant constituency at any transverse plane, and an obvious approach to sustained equality of condensing efficiency applied to all tubes on any horizontal line transverse of the tube bundle. (Paper by John H. Smith.)

TEXTILES

Elements of Cost in Dyeing Cotton Piece Goods

SOME of the elements that make up the cost of dyeing are given, after a discussion of the basis on which finishing plants do business. Wide differences in the financial set-up of the various finishing plants are so reflected in the indirect costs that such items as supervision, overhead, and other charges of a similar nature are not considered, and the costs are figured only on the basis of direct labor and cost of material. A development of the cost for each operation preceding the actual dyeing would be too extensive, and therefore the author assumes an average charge for the cloth received in the dyehouse with normal processing. The labor rates are averages taken from recent reports on the subject and do not represent the actual scale of any particular plant. (Paper by J. Andrew Clark.)

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Surplus Power From Industrial Plants

To the Editor:

In his article on "Surplus Power From Industrial Plants" in the November issue of Mechanical Engineering, Professor Christie, while rather limiting it to only a part of the problem, attempts to set up a basis on which utility systems and industrial plants may interchange power. The article is of interest because the author takes his stand somewhat intermediate to that of the utilities on the one hand and the industrial plants on the other. Reasonable as his conclusions may appear to those who have not really studied this subject and faced the realities of the present situation, they are far from equitable. As an engineer with an especial interest in industrial power problems, I have been actively discussing this situation for eight years and writing about it for three. Before the A.S.M.E. in December, 1930 (see Trans. A.S.M.E., paper FSP-53-26a, p. 346), before the Midwest Forestry Congress in December, 1931, and in a fairly complete article on the "Pooling of Power" as recent as the June 1, 1932, issue of *Power Plant Engineering* (p. 449), I have discussed the broader and more important aspects of this problem which each day is assuming greater and greater importance. So for brevity's sake I am going to make at once the rather anomalous statement that I have really refuted Professor Christie's conclusions before his article was written. I have refuted him as to at least two fundamentally important effects, namely:

1 Dump power *is* worth more than the incremental rate for similar power in the utilities' stations due to both the inevitable statistical effect and to its naturally scattered character.

2 Private industrial plants are just as much entitled to a fair profit for service they perform as are utilities.

In Professor Christie's article these two matters receive no consideration. This simply means that all the profits which accrue go to the utilities. Is it anything but fair and reasonable to ask upon what grounds he makes this tacit but fundamentally important decision? Are we going to develop still another field where the middleman takes all the profit? These are questions in which I know many industries are interested. They must of necessity be answered before Professor Christie can claim a solution to be fair or equitable.

Professor Christie devotes nearly a whole page to developing the sub-topic of "The Market Value of Surplus Power." He sharply focuses our attention on a *single* dump-power delivery and deduces that it really is not worth very much. I have directed attention to the fallacy of this method so many times that I almost feel it is a futile effort. I will not, therefore, repeat here what I have said and written before. Perhaps in any event a compelling analogy is more effective in revealing what I consider a serious error in Professor Christie's reasoning: Long years ago a very cautious Irish gentleman got word of the wonderful softness of feather beds. Wishing to possess one but unwilling to part with his limited money until assured of results, he asked to have a single feather sent as a sample. He took the feather, laid it on a large, flat rock, and stretched out on it. The next morning as he arose, stiff and sore, he was heard to mutter darkly, "Faith, if one feather is that hard, Lord save me from a feather bed." Deductions of this kind based on a single feather or a single dump-power delivery would appear to be hardly tenable. In analyzing feather beds or dump-power deliveries it seems to me highly essential to consider group or statistical effects to get the correct answer. Insurance, banking, thermodynamics, the very utilities themselves, each bears eloquent witness to the fact that there is regularity inherent in multitudinous irregularity. With hundreds, thousands, or even tens of thousands of industrial plants as potential members of power pools, to single out one plant and consider its dump-power effect is evidently a very special case.

From long acquaintance with this problem I feel that the present (which is essentially the past) attitude of the public-utility companies toward it will prove more and more untenable as the facts become better and better known. Professor Christie's article is itself substantiation of this view. But his solution could by no stretch of the imagination be regarded as an equitable one except on the premise that a tenth of a loaf for industrial plants is better than none at all. I believe that when the utilities finally get to the point where they are able to give this subject the serious thought and constructive consideration it deserves, they will find that good business *policy* as well as national *polity* calls for a measure of sharing here wholly consistent with that they have so widely advertised as customer-ownership but on a rather different basis. This basis I have broadly outlined in the article on the "Pooling of Power," previously referred to.

Guy B. Randall.[1]

Hamilton, Ohio.

To the Editor:

Referring to Professor Christie's article in the November, 1932, issue of Mechanical Engineering, parallel operation of industrial power plants with utilities has been a hobby of mine for some time. My opinions in this regard are the result of a number of years of operating experience in the utility business and an equal number of years of experience on the engineering and operating sides of industrial work. I think I can say without fear of contradiction that real fuel conservation can only be obtained by such operation. I am equally convinced however, that such a hook-up must not be made until a thorough study of the power conditions of the utility company on the one hand and the power and heat requirements of

[1] Superintendent of Power, Champion Coated Paper Company. Mem. A.S.M.E.

the industry on the other are made, in order to obtain a hook-up without too much capital expense.

The majority of central-station designers must learn that they have spent too much money in their layout: in other words, in making their design they must place the dollar and not efficiency first. On the other hand, the industrial operator must become a scientist instead of being an artist. I mean by this that I have yet to see any process concerning which "the reason why" cannot be determined by analysis instead of through the instrumentality of some mystic art that may have been handed down from father to son. When this idea becomes general it will be found that many heat processes can be properly handled with steam pressures well within the range of ordinary exhaust pressures, or extraction pressures possible with the average run of steam pressures.

The operating problems of a parallel hook-up do not seem to me to be at all complicated. In most cases where such hook-ups are liable to be made, the utility system is of a size that requires the load distribution to be handled by a load dispatcher; and as all the load dispatchers of my acquaintance are men who have had a thorough operating training, there is no reason why they should not rapidly absorb such knowledge of the industrial plant connected to their system as is necessary. The industrialist must come to realize the absolute necessity of a load dispatcher, because a power station connected to a transmission system and not operating under orders would make as much trouble as a train running wild on a railway.

As to the price to be paid by the utility company for by-product power, this also is a problem which requires careful analysis but is capable of solution. I think that Professor Christie's method of calculating this is a correct one, except that it seems to me that the utility company's investment is involved in this as well as the cost of fuel and labor. I feel that the utility should give the industrial plant some credit for relieving it of additional plant and transmission-line capacity.

To my mind no industry should buy a kilowatt-hour from a utility company when it can use the exhaust steam from the generation of such a kilowatt-hour—and conversely it has no business generating a kilowatt-hour unless it can use the resulting exhaust steam. This statement assumes that there is reliable power available at suitable rates. I wish to qualify this somewhat by adding that there is a minimum limit below which it would not be worth while for an industry to install generating equipment.

GROVER KEETH.[2]

Rothschild, Wis.

TO THE EDITOR:

In his discussion of my article in MECHANICAL ENGINEERING of November last, Mr. Randall has failed to appreciate the economics of the case. No utility or other industry will pay more for surplus power than the price at which that concern can generate the same power with equipment they already have installed and ready to run. That price is the incremental cost of generating a block of power equivalent to the surplus power available. This price—and no more—is all that the producer of surplus power can get for his service. Whether or not there is a profit in it for the producer, does not enter the problem. He must sell *at the market*, if he sells at all, and the market price is the utility's incremental cost. There is no sentiment or bias in these conclusions. They are dollars and cents' facts.

Mr. Keeth's discussion has particular value in view of his extended experience both with utility and with industrial plants. He correctly stresses the fact that such interchange of surplus power leads to real conservation of fuel resources. Mr. Keeth emphasizes the importance of correct understandings on the problems of the load dispatcher. Dissatisfaction can be the only result when both parties do not have mutual confidence in each other's efforts to effect a result for the common good of both.

Mr. Keeth holds that the industrial plant should receive some credit for relieving the utility of some additional plant and transmission-line capacity. This is true in the case of a supply of firm power from the industry. In the case of random supplies of surplus power, the utility has to provide the capacity in plant and transmission system to meet the demands at other periods than when surplus power is available.

The frank comments of the many who discussed the paper orally at the A.S.M.E. Power Division luncheon cannot fail to lend assurance to those engineers considering the question of surplus industrial power to encourage them to proceed further with their studies. The discussions will also indicate to the utilities that industrial engineers are interested in power interchange and are prepared to cooperate in the joint production of the cheapest possible power supplies.

A. G. CHRISTIE.[3]

Baltimore, Md.

Public Works and Recovery

TO THE EDITOR:

Referring to the communication of Mr. J. Billeter in the January issue of MECHANICAL ENGINEERING under the heading "Public Works and Recovery," while I agree that the effect of public works upon economic recovery may easily be overestimated, we cannot form a reliable estimate of the probable effect by simply considering the field labor, which in the examples given averages 21 per cent of the bid price.

Recovery is not merely a local problem, and as far as the country as a whole is concerned it is of little importance whether the labor is employed in the field or in the mine or factory producing material for the job.

In the last analysis, nearly all real values are created by labor. Values other than these are to a large extent fictitious or speculative, but even money paid out as returns upon fictitious values eventually goes into channels which employ labor.

Let us take, for example, the cast-iron pipe which is used upon a public-works job. The ore in the ground has little value, but as soon as work is done upon it, it begins to take on value, and even when work is done by machinery the value of the machine is chiefly created by labor, and its use upon the ore under consideration will bring nearer the time when new machines will be needed. The same principles apply to the transportation of the ore and the finished product, as well as throughout the whole process of manufacture.

The foregoing clearly shows that the increase in employment due to field construction work must be far greater than that indicated when only the labor actually employed in the field is considered.

The problem of estimating the actual increase of employment that may be attributed to any particular project, is too complicated to permit of an accurate solution; at the same time it is important that we should not seriously underestimate the

[2] Chief Engineer, Marathon Paper Mills Co. Mem. A.S.M.E.

[3] Professor of Mechanical Engineering, Johns Hopkins University. Mem. A.S.M.E.

effect of such projects through ignoring many of the factors involved. Nevertheless, it is perhaps not well to look upon an increase in the construction of public works as anything but a temporary economic booster, which, like most boosters, may at a later date act as a depressant.

For a permanent betterment we must look rather to an increased average consumption, or destruction, to supply the demand for labor, as the creation of fixed assets beyond those which can be profitably used will do more harm than good; in fact, it is quite clear that the chief causes of our present difficulties are too many frozen assets and too little consumption, and it may be pertinent to suggest that in practical effect there is often no difference between consumption and destruction.

It may appear, then, that there is great danger in attempting to increase consumption by increasing our frozen assets, therefore the real objection to a large increase in public works at the present time is not that it will give employment only to a comparatively small number of men, but that it may create more frozen assets—or perhaps we should say frozen credit—the result of which may not be felt immediately, but which will probably have a depressing reaction in the future.

JAMES O. G. GIBBONS.[4]

Newark, N. J.

Are We Too Efficient?

TO THE EDITOR:

During the last two years one eminent person after another has declared that our economic troubles were due to the fact that engineering and science have advanced too fast. They complained that the non-scientific activities of mankind, such as finance, government, business, and philosophy, have not been able to keep up with science. Consequently our entire social system is out of balance, and one of the results is business depression.

Scientists, on the other hand, maintain that their pace is very moderate; that their discoveries and improvements are insignificant compared with what remains to be discovered; and, therefore, that they must bend all their energies, employ all their knowledge and intellect, in order to accelerate the moderate rate of progress which they have attained.

This controversy puzzled the writer, and since its subject was so important, he decided to attempt a check-up.

Since engineers have made one of their most remarkable advances in automobile development, it would be interesting to know how much—or how little—further can they go in the development of automobile transportation before reaching perfection. From what we hear and read everywhere, one would suppose that if the engineer improved passenger auto transportation an additional 10 per cent it would attain 100 per cent, or perfection. Now let us see whether or not this assumption is correct.

The weight of a small five-passenger sedan is around 2500 lb. The weight of five average passengers will be about 800 lb. Therefore in order to transport a useful load of 800 lb a total load of 800 plus 2500, equal to 3300 lb, must be transported. This represents an efficiency of $(800 \times 100)/3300 = 24$ per cent in the load ratio. The next step is to determine the efficiency of the engine. According to numerous tests the average automobile engine can convert only one-fifth of the energy in the gasoline into power. In the language of science this represents a thermal efficiency of 20 per cent.

[4] Consulting Engineer. Mem. A.S.M.E.

Similarly the mechanical efficiency of the engine is 80 per cent, and that of the transmission machinery, 80 per cent. This makes the overall efficiency of automobile transportation of passengers $0.24 \times 0.20 \times 0.80 \times 0.80 = 0.03$, or 3 per cent.

We can see, therefore, that in one of his most successful lines of activity the engineer has attained an efficiency of only 3 per cent. In other words, he must advance 33 times as much as he has thus far in order to attain perfection.

If this progress seems too fast for philosophers, financiers, business men, and others, it seems so only because their own advance has been very much less than 3 per cent.

JAMES WINSTON.[5]

Union, N. J.

The Five-Day Week

TO THE EDITOR:

Why work at all? The answer is, because the standard of living is determined by the total production of the country, i.e., by the work we do, or which is done for us. The sole work done by some tropical negroes is to pick up fruit fallen from trees and to steal sweet potatoes and sugar cane and an occasional pair of cotton pantaloons; and as a result their standard of living is low. Our own high standard of living is determined by machine production; and machinery will produce proportionally more if run continuously, i.e., 168 hours a week, than if only run 40 hours.

It is idle to say that we have surplus producing capacity now. This may be apparently so; but it is only because we have concentrated production on the few needs and luxuries which have been intensively exploited to date. There are many other needs and luxuries that we know of now, and many, many others that the future will develop, which would serve to fully occupy the production capacity of the country if it were properly diversified; and which, if this were done, would result in a far higher standard of living than that we now enjoy. Even with this greatly increased production, automatic control of machinery may materially reduce the working hours of man; but the producing machines should run continuously. And in regard to the hours of work, let us not forget that too much leisure is as bad as too much work.

W. L. WATERS.[6]

New York, N. Y.

Adequate Purchasing Power

TO THE EDITOR:

In the October, 1932, issue of MECHANICAL ENGINEERING, under the title of "An Appeal for Constructive Thinking," Dr. Harvey N. Davis states as his first economic principle "Adequate Purchasing Power." I believe that adequate purchasing power, in the form of high wages and high salaries widely distributed among the masses, is fundamental to good business.

Prices are more sensitive to the economic barometer than wages. Prices react quickly as values appear or disappear. Wages, on the other hand, change slowly, due to the resistance of the wage earner to their decrease and of the employer to their increase. Therefore prices on the uptrend from a depression logically rise faster than wages, and hence, obviously,

[5] Assoc-Mem. A.S.M.E.

[6] Bury and Waters, Consulting Engineers. Mem. A.S.M.E.

the community's purchasing power must lag correspondingly.

Dr. Davis suggests that the unemployed engineers of the country should be mobilized, at relief wages, to supervise the expenditure of a bond issue for public and quasi-public works, and that the labor involved should be paid for at relief wages. I cannot agree with the "relief wages" part of Dr. Davis' suggestion. No one can quarrel with the fact that prices and wages must be reduced in our present emergency, but the sacrifice, I most emphatically maintain, should be borne justly and in proportion by rank and file alike.

To my way of thinking it is preposterous to expect engineers to manifest any amount of initiative and efficiency under a scale of relief wages, and it is only natural to assume that projects erected under Dr. Davis' plan would cost far more than he anticipates.

To recapitulate, I believe that industry could very well sponsor a program of relief in our present emergency by discontinuing its present policy of retrenchment in personnel and substituting therefor a policy of taking back not only old employees, but in many instances new ones as well. Obviously, twenty men working half time, by the above token, would do more to keep the wheels of industry and commerce turning than ten men working full time. In other words, the maximum spreading of work at the present time will go a long way toward restoring adequate purchasing power and the creation of normal jobs.

JOHN F. ROCRAY.[7]

Jersey City, N. J.

Engineers and Economics

TO THE EDITOR:

The introductory paragraph and many of the suggestions contained in Mr. R. E. Kinsman's letter published in the November, 1932, issue of MECHANICAL ENGINEERING are intensely interesting and helpful. However, I must point out, in defense of accurate thinking by engineers, that Mr. Kinsman's letter contains two violations of his own advice.

"Don't generalize" as applied to assuming that isolated cases prove a point, applies equally well to the fault of assuming that partial likeness proves objects or plans to be "essentially" the same. The mushroom and toadstool are not essentially the same, even though they so appear without careful examination.

Had Mr. Kinsman attacked the probable practical benefits that might be derived through application of the plan outlined in my letter in the August issue, I should have chuckled in hearty appreciation, but to overlook its distinguishing virtues because of a mechanical similarity to the union-label idea and to dismiss it as "essentially" the same is plain generalization and failure to detect the distinct differences from the latter idea, with which, no doubt, all engineers are familiar.

The same advice, "Don't generalize," and in addition the advice to "be suspicious" of the conclusions of writers who give no proof, may both be applied to Mr. Kinsman's comments on the single tax. While the principle of land-value taxation is indeed old, the student of economics will find worthy opinion to the effect that its failure to have previously found practical application is because it was advanced before the world was ready for it, and that it must eventually come into its own. In any case, to infer that it has had an earnest and comprehensive trial and been found wanting is an absurdity.

We *are* all amateurs in the science of economics, and therein lies one of the best reasons why engineers may be of service in the struggle to restore and maintain true prosperity. Trained to search for the truth, yet unfettered by precedent or befogged by close personal interest, engineers, once awakened, are preeminently qualified to apply the acid test of logic to economic problems. Many old ideas now dormant or abandoned may need be resurrected and placed in their proper place.

Engineers! Study the past, but plan the future on your own conclusions!

A. E. KITTREDGE.[8]

Haddon Heights, N. J.

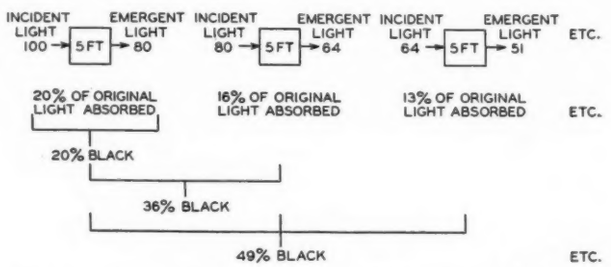
[7] Jun. A.S.M.E.

Smoke-Density Scales

TO THE EDITOR:

The Ringelmann scale in which 20 per cent black denotes No. 1 smoke, 40 per cent is No. 2, 60 per cent is No. 3, and 80 per cent is No. 4, is not an accurate scale for grading smoke. It precludes accurate smoke-density determinations for two reasons: (1) The diameter or thickness of the smoke stream is not taken into consideration; and (2) the scale is predicated on the incorrect supposition that 20, 40, 60, and 80 per cent light absorptions correspond to concentrations varying as Nos. 1, 2, 3, and 4, respectively.

A scale which may be employed for determining density or concentration on a stream-volume basis is described in what follows. If it is assumed that 20 per cent absorption applies to a smoke stream the diameter or thickness of which is 5 ft, the problem then is one of determining comparable values for other thicknesses and concentrations. The following graphically shows that a density of 20 per cent in the case of a 5-ft smoke stream is equivalent to 36 per cent in the case of a 10-ft stream, 49 per cent in the case of a 15-ft stream, etc.



Likewise, values for Nos. 2, 3, and 4 for various thicknesses may be obtained, and finally the complete scale is:

Thickness of stream, ft	No. 1	No. 2	No. 3	No. 4
5	20	36	49	59
10	36	59	74	83
15	49	74	87	93
20	59	83	93	97
25	67	89	96	99

Thus smoke density on a comparable basis varies, for example, in the case of No. 3 smoke, between 49 and 96 per cent, depending upon the thickness of the smoke stream.

From the foregoing it is apparent that 20, 40, 60, and 80 per cent light absorptions are not comparable with dust or smoke concentrations varying as Nos. 1, 2, 3, and 4, respectively, even for one particular thickness of smoke stream.

H. E. BUMGARDNER.[9]

Detroit, Mich.

[8] 411 Fourth Ave. Mem. A.S.M.E.

[9] Research Department, The Detroit Edison Company. Assoc. Mem. A.S.M.E.

RESEARCH—CODIFICATION

Notes on Work of Technical Committees of the A.S.M.E., Etc.

Research

Elevator Safety Advanced by A.S.M.E. Research

WITH the rapid development of the high-speed and long-rise elevators required by the tall buildings of today, adequate provision for the safety of passengers has become of paramount importance as the problem of control under both normal and emergency conditions has grown more difficult. Foreseeing this situation the A.S.M.E. Special Research Committee on Elevator Safeties was organized in 1925, with a personnel which included engineers representing elevator, building, insurance, and governmental interests. The purpose was to establish well-substantiated design data for safety devices, develop methods of test for the approval of such devices, and recommend needed changes in existing safety codes.

Tests of hydraulic buffers have been completed and a study of under-car safeties is now going on. These tests have been conducted on an experimental elevator installed by the Committee in a six-story hoistway provided by the Bureau of Standards in Washington. Two research associates have been employed over the past eight years on the investigational work, which has cost $85,000 to date. Elevator and accessory manufacturers and insurance companies have contributed most of the funds, which have been held by the A.S.M.E. and disbursed under the direction of the Committee. Manufacturers have been provided with data which they have used in building their safety devices. At the same time the knowledge obtained from this experimental work has been used in interpreting and revising the American Standard Safety Code for Elevators, the last edition of which was published in 1931. This code, which covers the construction, installation, maintenance, and operation of elevators, dumbwaiters, and escalators, has been adopted in whole or in part by many states and municipalities for regulatory purposes and by manufacturers, architects, and building owners as a standard reference for safe practice.

Unfortunately, it appears that the experimental program will soon have to cease because of shortage of funds. Owing to the great falling off of business in the building industry, most of the former contributors are not continuing their support at this time, although they consider the work of great value and expect to make further contributions when business improves. The safety of the public has been well protected by the work of the Committee, and it is hoped that the continued moral support of the public can be relied upon to maintain the present high standards that have been attained.

The special test instruments developed as a result of the Committee's research program are of general interest and may have wide application in the engineering field. For example, the long-stroke pressure recorder might be adapted to provide full-length records of pressures within the cylinders of steam engines running at moderate speeds, or in the study of gun recoil cylinders and of buffers for airplane catapults and similar equipment. The high-speed camera developed might be applied to provide stroboscopic motion pictures of internal-combustion engines and similar equipment; or find use in the study of vibration in airplane propellers or the vibration in such structures as airplane fuselages. The governor-rope tension recorder developed immediately suggests such uses as the recording of variations in tension in the main support cables for elevators, cranes, hoists, and similar mechanisms.

Thus, as in most research projects, there is a considerable amount of by-product value in the instruments and methods developed to meet the conditions encountered in solving specific problems. Information concerning details of the work of the Committee or the devices and methods it has developed may be obtained by addressing The American Society of Mechanical Engineers.

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretation of the Committee in Cases Nos. 742 and 746 to 750, inclusive, as formulated at the meeting of January 13, 1933, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 742

Inquiry: Par. P-288*b* requires independently fired superheaters which can be shut off from the boiler to be provided with safety valves having a discharge capacity based on Par. P-270. How may the size of safety valves for such superheaters be more definitely determined, and would more than one safety valve ever be required?

Reply: It is the opinion of the Committee that the intent of the reference to Par. P-270 will be met if the capacity of the safety valve or valves installed is equal to 6 lb of steam per hour per sq ft of superheater surface measured on the side exposed to the hot gases. The number of safety valves installed shall be such that the total capacity is at least equal to that required.

CASE NO. 746

Inquiry: Is it necessary, under the requirements of Par. P-310 of the Code, that pipe fittings in blow-off lines be of steel, or

does Par. P-12 permit of the use of cast-iron fittings for this purpose?

Reply: Par. P-12 is a general rule pertaining to pipe connections and fittings, but the Committee points out that Par. P-310 specifically requires all fittings in blow-off lines between the boiler and the blow-off valves to be of steel.

CASE NO. 747

Inquiry: Par. P-195 specifies which diameters shall be used in determining the radius of spherically dished heads attached by riveting. What corresponding diameter shall be used for heads attached by butt welding, when the heads and shell plates are the same thicknesses, and when they are of unequal thicknesses that require thinning as provided in Par. P-104?

Reply: It is the opinion of the Committee that in all cases when dished heads are attached to shells by butt joints, the inside diameter of the thinnest portion of the shell plate shall be used in applying the rules of the Code.

CASE NO. 748

Inquiry: Pars. P-180 and U-20 provide that if the thickness of the weakest course of a shell is over 10 per cent of the radius, the outer radius of the shell shall be used in computing the maximum allowable working pressure. If a shell is so made that the thickness of a portion of the circumference exceeds 10 per cent of the radius, while the thickness of other parts of the shell measured on the same circumferential plane is less than 10 per cent of the radius, which thickness shall be used in calculating the allowable working pressure?

Reply: It is the opinion of the Committee that the maximum allowable working pressure shall be the lesser of those calculated for each diameter and thickness in accordance with the requirements of Pars. P-180 and U-20, using the radius, thickness, and longitudinal efficiency in each case.

CASES NOS. 749 AND 750

(In the hands of the Committee)

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-12*b*. ADD THE FOLLOWING:

(SEE PAR. P-310 FOR BLOW-OFF CONNECTIONS.)

PAR. P-190. REVISED:

P-190. In horizontal-return tubular boilers with longitudinal lap joints, no course shall be over 12 ft. long. With butt [and double-strap] joint construction, [longitudinal joints of] any length may be used. [provided the tension test specimens are so cut from the shell plate that their lengthwise direction is parallel with the circumferential seams of the boiler, and the tests meet the standards prescribed in Specifications S-1 for Steel Boiler Plate.]

PAR. P-195 AND U-36. ADD THE FOLLOWING SENTENCE TO THE ELEVENTH SECTION OF PAR. P-195 AND THE TENTH SECTION OF PAR. U-36:

WHERE A BUTT JOINT IS USED, THE INNER DIAMETER OF THE THINNEST PORTION OF THE SHELL SHALL BE USED IN APPLYING THESE RULES.

PAR. P-269. REVISE FIRST SENTENCE TO READ:

P-269. *Safety-Valve Requirements.* Each boiler SHALL HAVE AT LEAST ONE SAFETY VALVE, AND IF IT HAS [having] more than 500 sq ft of water heating surface, or [in which] the generating capacity exceeds 2000 lb per hour, IT shall have two or more safety valves.

TABLES A-5 AND A-6. TO BE REVISED TO CONFORM TO AMERICAN STANDARD B16e-1932 ON STEEL FLANGED FITTINGS AND COMPANION FLANGES.

PAR. H-80. OMIT.

PAR. L-42. REPLACE "*P*" IN THE FOURTH LINE BY "*p*."

PAR. U-31. REVISE THE SECOND SECTION TO READ:

When a vessel is used for a purpose that makes it necessary to provide in its construction for extraordinary wear, corrosion, or other deterioration in service, and plates of greater thickness are used than would otherwise be required, the longitudinal joints of shells exceeding $\frac{1}{2}$ IN. IN THICKNESS [48 in. in diameter] may be lap riveted if the following conditions are met:

PAR. U-64. REVISED:

U-64. *Hydrostatic Test.* Each vessel constructed under these rules shall be tested under hydrostatic pressure to not less than $1\frac{1}{2}$ times the maximum allowable working pressure. For vessels of fusion-welded construction the requirements of Par. U-77 shall apply. EXCEPTIONS: [except that] for enameled vessels the test pressure need not exceed the working pressure; FOR gas-storage vessels which are too large to withstand safely the weight of the large mass of water required to fill them for hydrostatic test, THEY may be tested by compressed air at a pressure not to exceed the maximum allowable working pressure of the vessel.

PARS. U-69 AND U-70. ADD THE FOLLOWING AS A FOOTNOTE:

By "lethal substances" are meant poisonous gases or liquids of such a nature that a very small amount of the gas or vapor of the liquid mixed or unmixed with air when breathed is dangerous to life. For purposes of this Code, this class includes substances of this nature which are stored under pressure or may generate a pressure if stored in a closed vessel. Some such substances are hydrocyanic acid, carbonyl chloride, cyanogen, mustard gas, and xylyl bromide. For the purposes of this Code ammonia, chlorine, natural or manufactured gas, propane, or butane are not considered as lethal substances, but it was the intention of the Committee that their storage should not be permitted in Class 3 pressure vessels.

PAR. U-96. REVISE THE FIRST SENTENCE TO READ:

Heads shall be INSERTED [driven] into the shells with a tight DRIVE OR SHRINK [driving] fit, and shall be thoroughly brazed in approximately the same manner as the longitudinal seam for a depth or distance from the end of the shell equal to at least 4 times the thickness of the shell metal.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets, and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

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BARDELL *vs.* PICKWICK—*A Review of Technocratic Literature*

THROWING open the shutters one morning last summer the engineering profession, with the guilelessness of Mr. Pickwick, looked out upon its Goswell Street. Goswell Street lay on either hand and directly over the way; but philosophic speculation on the narrowness of such views as Goswell Street afforded were cut short by the astounding discovery that Mrs. Bardell's boy Technocracy was bawling lustily about Mr. Pickwick's perfidy, while the tongues of idle gossips claqued noisily, and accusing eyes were raised to the windows of the "first floor front." Hastily withdrawing its head, and with premonitions of the insidious interpretations that Sergeant Buzfuz would put upon the innocent mention of "chops with tomato sauce," "slow coach," and "warming pan," the profession, in the person of Mr. Pickwick, set out for the Guildhall to face the court of the world and to explain as best it could the name that Mrs. Bardell's boy had appropriated, and what Mr. Pickwick had meant when he asked if he wanted a new father.

At the subsequent trial, with Howard Scott as Mr. Sergeant Buzfuz, eminent technocrats testifying in the manner of Mr. Nathaniel Winkle, and Allen Raymond as the irrepressible Samuel Weller, the finding of the jury was for the plaintiff. No amount of righteous indignation could free engineering from the sensation aroused by Technocracy, and the implications of responsibility that were attached. Friends of the profession shook their heads with the mournful expression of the elder Weller and muttered, "Oh, Sammy, Sammy, vy worn't there a alleybi!"

And so, as the profession languishes in the Fleet, wondering what it's all about and musing on the "price system" and the "theory of energy determinants," and speculating on its "next most probable energy state," it is appropriate, for purposes of the record, to deal briefly with the sensation of 1932 that is known to the world as Technocracy.

Not in many a year has a word, unsupported by popular understanding of what it might mean or imply, received such sensational publicity as did "Technocracy" from August 21 to January 24. These five months witnessed a meteoric rise that reached its height about the middle of January when, at an important dinner, the facilities of a broadcasting network turned out to be the Nemesis of the left wing and led to the schism within the metropolitan ranks that was a prelude to a rapidly waning public interest.

The history of these five mad months is what the average person has heard of Technocracy. Allen Raymond[1] covers the important developments in his book, and goes back to the earlier history that was little known and largely forgotten. He attributes the coining of the word "Technocracy" to William H. Smyth, who wrote an article in the March, 1919, issue of *Industrial Management* entitled "'Technocracy'—National Industrial Management—Practical Suggestions for National Reconstruction." Mr. Raymond traces the present movement back to the "Technical Alliance," a group that included Thorstein Veblen, Charles P. Steinmetz, Howard Scott, Frederick L. Ackerman, and Bassett Jones, and brings it down to 1932 when Professor Walter Rautenstrauch showed his active interest by offering the hospitality of the Department of Industrial Engineering at Columbia University to a group of unemployed architects who, under the directorship of Howard Scott, undertook the plotting of statistics of population and production growth—the now famous "Energy Survey of North America." The principal interest in Mr. Raymond's book is of the human variety, for it describes the men whose names have been chiefly mentioned in connection with Technocracy. It is based on the four articles that appeared late in 1932 in the New York *Herald-Tribune*, over Mr. Raymond's signature, in which the legends that had been springing up about Mr. Scott were witheringly laid low.

The fall of 1932 seethed with technocratic ferment. Wayne W. Parrish, in a series of articles that began in the November issue of the *New Outlook*, entitled "What Is Technocracy?"[2] placed the name and the doctrine before a national audience. The more serious-minded critics, led by J. H. Van Deventer of the *Iron Age*, attacked the authenticity of the figures quoted by Mr. Parrish as coming from the group working under Mr. Scott. Denials, explanations, recriminations flew recklessly among the disputants.

By December it seemed as though a bad case of depression jitters would seize the country. Then the humorists began to be heard, and Will Rogers, and such eminent radio entertainers as Amos 'n Andy, Ed Wynn, and Eddie Cantor seized upon the new word and an awakening national interest to spread their mirth.

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[1] "What Is Technocracy?" by Allen Raymond. Whittlesey House, McGraw-Hill Book Co., Inc., New York, N. Y.

[2] Now revised and available in book form as "An Outline of Technocracy," by Wayne W. Parrish. Farrar and Rinehart, New York, N. Y.

"Enthusiasm," said Robert Browning, "is the thing, only you can't command it." And such, apparently, was the difficulty with the enthusiasm with which Mr. Howard Scott played his part as "chief technocrat" on a stage ablaze with the light of national publicity. The university which had hospitably opened its doors to the cartographers of the "Energy Survey" was obviously embarrassed. Professor Rautenstrauch made address after address, notably one at Atlantic City before the American Association for the Advancement of Science, in an endeavor to pour the oil of engineering reasonableness upon the troubled waters of uncontrolled sensationalism. Official denials that Columbia was a sponsor to the technocratic doctrine were forthcoming. But the sensation was beyond such control. College presidents, industrialists, bishops, editors, congressmen, even Mussolini, and the American Engineering Council commented and, generally, denounced. Technocracy's dire predictions as played up in the press were too terrible for a people in the depths of a depression to face, and the writings of Howard Scott were couched in language none could understand. Mr. William Hard, over the radio on the night of January 3, made humorous allusion to the technocrats on this ground as the "veiled prophets of Khorassan;" who are followed because no one understands them.

The end came swiftly. An unavoidable schism between Howard Scott, representing what may be called the left wing of Technocracy, and those who make up the right was publicly proclaimed on January 23. The name "Technocracy" went with Scott. Professor Rautenstrauch, who bore the brunt of the publicity as representing the right wing, continues to carry on a study looking to a "design of society in which class struggle is impossible and to discover those principles upon which public enterprise may be founded. . . . a social system under a balanced quantitative control of production, distribution, and consumption."[3]

Now that the excitement has died down, it is proper to ask what it was all about. Popular interpretation of such matters as technological unemployment, a soviet of engineers, energy currency, and the obsolete price system reacted unfavorably to the cause. Statistics were shown to be ridiculously extrapolated or were quoted loosely so as to be easily controverted, as in the case of iron and brick production. Mr. Raymond deals with these criticisms in his book. But the doctrines and implications of Technocracy as a social philosophy were as badly misunderstood, as inaccurately quoted, and as extravagantly extrapolated as the census statistics.

It is generally conceded that the source book of Technocracy's social doctrine is Thorstein Veblen's "The Engineers and the Price System,"[4] written in 1919, and containing as a final chapter "A Memorandum on a Practicable Soviet of Technicians." Veblen inveighed against capitalism, "vested interests," "kept money," and looked to technicians to provide a new social, economic, and political order that would be purged of the price system and other capitalistic errors. His plan for accomplishment was outlined in his book. "Any plan of action," wrote Veblen, "must engage the intelligent cooperation of several thousand technically trained men scattered over the face of the country, in one industry and another; must carry out a passably complete cadastration of the country's industrial forces, must set up practicable organization tables covering the country's industry in some detail—energy resources, materials, and man power; and it must also engage the aggressive support of the trained men at work in transportation, mining, and the greater mechanical industries. . . . And it is obvious that so soon as they (the technicians) shall draw together in a reasonably inclusive way, and take common counsel as to what had best be done, they are in a position to say what work shall be done and to fix the terms on which it is to be done. . . . The obvious and simple means of doing it is a conscientious withdrawal of efficiency; that is to say, the general strike, to include so much of the country's staff of technicians as will suffice to incapacitate the industrial system at large by their withdrawal, for such time as may be required to enforce their argument. . . . By themselves alone, the technicians can, in a few weeks, effectively incapacitate the country's productive industry sufficiently for the purpose." Scattered, but significant quotations.

Veblen concludes his memorandum by reminding his readers that production engineers are a "scattering lot of fairly contented subalterns, working piecemeal under orders from the deputies of the absentee owners. . . . There is nothing in the situation that should reasonably flutter the sensibilities of the Guardians or of that massive body of well-to-do citizens who make up the rank and file of absentee owners, just yet."

In a modest publication[5] admitting to be "the only authorized presentation," it is stated that Scott and Veblen "had come to quite similar conclusions concerning the operation of the Social Mechanism"—Scott by way of physical science and Veblen by hacking his way through the preconceptions of economic science.

In their treatment of "price" it is difficult to distinguish between the two points of view. To both, "price is an independent variable that intrudes and, through its controls, serves to throw the system out of balance." Nor is there any important distinction to be drawn from their handling of debt.

The "Introduction to Technocracy," therefore, may be looked upon as the approved thesis of the "Continental Committee on Technocracy" and Mr. Scott. It contains two principal documents; Part I, "The Technologist Looks at the Depression," which is obviously the manuscript summarized by Mr. Raymond and attributed by him to Mr. Frederick L. Ackerman; and Part II, written by Mr. Scott and appearing originally in the *Living Age* for December, 1932.

In looking at the depression the technologist of the authorized "introduction" notes two periods of human society, differentiated, in terms of energy conversion by mankind, into one of comparatively slow change—the non-machine society in which man himself is the chief engine, and the machine society, possessing engines for the conversion in great amounts of extraneous energy. "For six thousand years of social history," says the technologist, "no change in the rate of doing work was effected except that in the metabolism of the human engine of conversion due to dietary changes. Within the last hundred years we have multiplied the original output rate of that human engine by 9,000,000, in a modern energy-conversion unit."

This, of course, is familiar ground for mechanical engineers. It is the consequence of this rapidly accelerating rate of doing work on society that concerns the technologist. First, he sees society "face to face with an immediate depletion of energy and mineral resources in combination with this rising productive capacity." Of the points involved here, the technologist considers first that of rate of production, and calls attention to the points of inflection that appear to have developed in all of the rate of-growth curves plotted for the various industries,

[3] Elsewhere in this issue will be found an abridgment of the address by Professor Rautenstrauch before the Metropolitan Section of the A.S.M.E. from which these phrases are quoted.—EDITOR.

[4] Published originally in book form in 1921 by B. W. Huebsch, Inc.; republished in 1932 by The Viking Press, New York, N. Y.

[5] "Introduction to Technocracy," by Howard Scott and others. The John Day Company, Inc., New York, N. Y.

converting them from a parabolic to a hysteresis form.[6] By plotting curves of man-hours per unit, the technologist finds them to decline, "approaching the limit of zero in all our best practices." This introduces the familiar problem of technological unemployment.

Now, for the price system!

The technologist notes that the increase of energy consumption per capita per day from 2000 to 150,000 kilogram calories constitutes a fundamental social change which is susceptible to measurement in physical units. While this technologist is working in a world of "materials, energy resources, quantitative relations, and rates of energy conversion," for which unvarying standards of measurement exist, he lives simultaneously under a price system within which all measurements are made by a "pecuniary standard that is continuously variable." This "constitutes a situation that is obviously alien to the technologist's world of thought, theory, and action. Furthermore, he notes that the magnitude of pecuniary wealth is equal to the debt, and that "pecuniary wealth cannot be created without first creating a corresponding item of debt;" that these items are "purely fictitious," but they serve the purpose for which they were created; i.e., "they serve the distributers of the control of industry, not its materially productive work."

"Price" and "Value," therefore, "are the fine-spun theories of philosophers and economists who have attempted to surround these terms with the semblance of meaning," and are measured in the variable unit—the dollar. Furthermore, under the price system the making of a monetary profit and the payment of interest on the capital invested in the industry are involved in successful operation. The profit motive is responsible for an increasing production rate. Interest is bad enough in itself, but the paying of it involves the plowing back into capital investment of a considerable portion of it. The steps by which such an unreasonable impasse as that represented by present conditions is reached are then developed. From these considerations it is deduced that "any scheme of social organization designed to utilize our resources and ability under conditions of security, offered by technology in the name of science, will involve the disallowance of the price system." And to science, as modern civilized men, we turn.

Part I proposes no tangible substitute for the price system; but in the second part, accredited to Howard Scott, we read in his own language, the following:

"Any unit of value under a price system is a certification of debt. Any unit of measurement under a technological control would be a certification of available energy converted. Such units of certification would have validity only during the balanced-load period for which they were issued. This method of producing physical wealth and measuring its operation precludes the possibility of creating any kind of debt. It also eliminates the entire domain of philanthropy. Furthermore, all bonds, financial debentures, and other instrumentalities of debt would cease to exist, since they do not have one iota of usefulness in the physical operation of such an area under technological control."

"Technology proposes no solution," writes Mr. Scott with cold comfort for a distraught humanity. But of one thing there is certitude: there is no choice "but to proceed with the further elimination of toil through the substitution of energy for man-hours." Thus do the furies of progress pursue man over the uncharted and uncertain pathway of societal evolution.

Turning now to a writer more successful in suiting his expressions to the understanding of ordinary readers, Stuart Chase,[7] we find an interpretation of Technocracy not difficult to understand. In thirty-two easily read pages, Mr. Chase sketches the background, considers the attack on Technocracy, visualizes the world without money, discusses energy and civilization, poses the basic technocratic formula of growth that varies as some power of time, and ends by asking, and to some extent answering, the question, "What is wrong with this picture?" Mr. Chase's philosophy coincides roughly with Technocracy's. He cannot, he concludes epigrammatically, take his energy economics straight—he requires a "chaser" of psychology and anthropology. So others have thought and said, less arrestingly.

The volume of technocratic literature, mostly apocryphal, is great. The end has not been reached by any means. Magazine articles, explanatory and critical, are featured month by month. Of the books, only a few have been mentioned in this review. Many of them have been accorded prominent notice in other reviews. Lists of titles have appeared from time to time to bear witness to the increasing brood. But one more will be mentioned here. It is a picture of life in a technocracy,[8] written by an admirer of Howard Scott who makes it clear that while conversation and association with Mr. Scott prompted the ideas, their expression by the author has no official blessing. Of all technocratic literature that the present reviewer has read, Harold Loeb's "Life in a Technocracy" is the most stimulating. In flights of fancy into a future "rendered closer to the heart's desire," any imaginative person may freely follow, sure that his enthusiasms and fears alike condemn him to no permanent sojourn. When the last page is turned and the call to tomorrow's tasks brings the reader back to office or studio, there is still about him the familiar environment for which he has the affection bestowed on an old suit, even though it be thin and shabby.

Across the River Weser and into Koppelberg hill, Harold Loeb leads us as the Pied Piper led the children of Hamelin. There "honey bees have lost their stings and horses are born with eagles' wings." It is not inappropriate to remind the reader parenthetically that the joyously dancing children of Hamelin were lured to the distant paradise because of the breakdown of the price system—what appeared to the Mayor to be an unjustified debt. And it is by means of the abolition of the price system that Piper Loeb leads us into the technocratic state of the future.

Mr. Loeb starts in the blind alley of our present capitalistic state, from which escape seems possible to him only by way of the inevitable evolution into a technocracy. He makes clear, and reasonably attractive, life in this future state. He shows how individual income will be determined by dividing total energy production per year by the total population, and how the energy certificate, non-transferable and canceled at the end of the year, if not totally consumed, will be issued, spent, and provide what is technocracy's object, "the material needs of each member of the community at a minimum expense of human effort." The advantages and benefits of the new system are persuasively set forth. Answers to some natural objections are provided. Such important questions as those relating to government are discussed. Religion, which will not disappear, becomes, apparently, a code which is freed of ignorant taboos and says, " 'Do that which is good for you.' Its only

[6] In his address before the American Association for the Advancement of Science, Professor Rautenstrauch gave consideration to the nature of growth curves, and included a discussion of the Pearl-Reed equation for population growth which, with proper constants, appears to represent the growth data of a wide variety of phenomena.—EDITOR.

[7] "Technocracy, an Interpretation," by Stuart Chase, The John Day Pamphlets, No. 19, The John Day Company, New York, N. Y.

[8] "Life in a Technocracy," by Harold Loeb, The Viking Press, New York, N. Y.

prohibition would be acts definitely anti-social." But anti-social acts under technocracy have little temptation for man when so much ignorance has been banished and the price system and the profit motive eliminated. Education is provided for, and for practical purposes would be taken care of by industrial schools. Amusement has its place—"provision must be made for pleasure stimulations" to banish discontent in the midst of leisure. Art, in a technocracy, "will probably become . . . the most important field of human endeavor."

"Technocracy alters our conceptions of vice. . . . Sexual aberrations would be condemned only when they injured society." Surliness is unaffected, but "adultery . . . cannot exist as such in a technocracy." "Drunkenness would not disappear," but "jealousy of another's possessions is largely done away with."

Family life takes on a different meaning as sexual selection has freer play, and the race in a technocracy tends to develop the "high faculties" in every man. There would be a national striving to develop by this means the amiable graces of technocratic society—beauty, intelligence, refinement, efficiency, vitality, and the gift for esthetic expression. The ultimate is summed up by Mr. Loeb in saying that "A technocracy, then, should in time produce a race of man superior in quality to any now known on earth, a society more exciting, interesting, and variegated than has ever been possible, and a nation in which no individual should be unhappy or discontented for remedial causes."

How are we to attain to this enviable estate? Mr. Loeb tells us. "The inauguration of a technocracy depends on outside forces rather than on leadership." With revolution and evolution as possibilities we learn that "Technocracy may possibly be installed by a combination of both. . . . The evolutionary process is to be preferred."

"Revolution in America," Mr. Loeb concludes, "should neither be desired nor expected now," and since evolutionary processes are most likely, an outline of them is presented. First a few persons must organize for the coming crisis. Second, the Sherman Anti-Trust Act should be repealed so that, third, the major corporations may gobble up their competitors. Fourth, the profits of monopolies should be limited. Fifth, technological economies should be handed on either to the worker or the consumer, and sixth, the present price system, "ingenious and nonsensical," must go by the board.

In reviewing the steps he proposes, Mr. Loeb sees the greatest difficulty arising with respect to the third, because a law by which a corporation is encouraged to gobble up its competitor "outrages the dearest convictions current today. It is a denial of economic freedom, and the benefits of capitalism are all credited to this freedom. It may prove impossible to pass such a law." Thus we come to the conviction that "the main obstacle hindering the advent of technocracy is the present faith, the Mysticism of Money."

Such a sketchy presentation of some of the high spots of Mr. Loeb's interesting picture of life in a technocracy does it no adequate justice. It is easy and pleasant reading, and will stimulate much thought. One cannot, however, refrain from suggesting that the reader who finds Mr. Loeb too agreeably persuasive should read, not necessarily as an antidote but perhaps for the sake of a historical background, that absorbing story of societal evolution written for popular consumption by Prof. A. G. Keller, and appropriately called "Man's Rough Road."[9] The tough fiber of humanity is woven into the pages of this book. At man's dawn he faced what Professor Keller calls "the awkward situation." Today he still is facing it, and—would it be too heartless to predict that under a technocracy awkward situations will still arise?

Visions, apocalyptic and utopian, have engaged men's fancies from the beginning of time. They have served to make sufferable such earthly environments as Patmos and London, and to lead men to hope and to plan. But they can never quite obscure the fact that "the common problem. . . . . is not to fancy what were fair in life provided it could be—but, finding first what may be, then find how to make it fair up to our means: a very different thing," and, it may be added, a philosophy that appeals to most engineers.

This review began with a reference to that beloved antiquarian, Samuel Pickwick, Esq., G.C.M.P.C., who presented to the world the celebrated Tittlebatian Theory and who ran afoul of the meanness of humanity by being haled into court on a trumped-up breach-of-promise suit. It was suggested that engineers have felt similarly abused by having the sensation of Technocracy laid on their doorstep. Few engineers would subscribe to Veblen's "Soviet of Technicians," yet many statements in this and in technocrat literature might conceivably issue from the mouths of the most conservative, with altered meanings and implications.

For example, in a pamphlet recently published by the Engineering Foundation,[10] we read, "Politics . . . is largely a task for the engineer," and in accepting the Hoover Medal in recognition of distinguished public service, Mr. Hoover said: "Every county government, every municipal government, every state government, and the Federal Government itself, is engaged in constant attempt to solve a multitude of public relationships to those tools which the engineers . . . place on the very doorstep of the Government. And in solving these problems we have need for a large leavening of engineering knowledge and the engineering attitude of mind and the engineering method. . . . It is for these reasons that the engineers . . . can contribute to the solution of the problem which arises from their own creation. . . . I am not advocating that all public service be turned over to engineers. . . . but the engineers . . . have a contribution to make to public service and they have obligations to give that contribution . . . "

The present reviewer cannot presume to speak for engineers, but he makes bold to suggest that most of them are humble enough, and wise enough, to feel that they would be no more adept at government than any other group of specialists, and that their contributions to what Mr. H. G. Wells calls the civil service, in departments where their knowledge and abilities are most valuable and appropriate, constitute what they think of, as a group, as services to politics and statecraft, although individually they may aspire, as do men of other types, to political leadership. There seems to be little cry among them for a soviet of engineers.

Perhaps the moral of this technocratic review should be an admonition to engineers to contemplate more seriously the very close relationship that their calling has to human welfare and happiness. The blinding of the eyes of reason to the obvious problems of an industrial civilization is dilatory and unheroic. Destructive alarmist views that create fear and unrest, without hinting at solutions or offering constructive suggestions that can be put into immediate practice, are iniquitous. But sober and serious study of a problem in the light of an inspiring ideal and by the approved methods of engineering science, such as Professor Rautenstrauch describes in the leading article of this month's MECHANICAL ENGINEERING, is worthy of consideration.—G. A. S.

[9] "Man's Rough Road," by A. G. Keller, Frederick A. Stokes Co., New York, N. Y.

[10] "Engineering, a Career, a Culture, a Message to Young Men, to Parents and Teachers." The Engineering Foundation, New York, N. Y.

WHAT'S GOING ON

The American Engineering Council

THE Assembly of the American Engineering Council held its annual meeting at its headquarters, 744 Jackson Place, Washington, D. C., January 13–14, 1933, which was attended by more than fifty representatives of the national, state, and local engineering societies comprising the Council. John F. Coleman, of New Orleans, member of the Engineers' Advisory Board of the Reconstruction Finance Corporation and a past-president of the A.S.C.E., and William H. Woodbury of Duluth, past-president of the Minnesota Federation of Architectural and Engineering Societies, were elected vice-presidents for the two-year term, 1933–1934. Farley Osgood was re-elected treasurer for the term of one year, and A. J. Hammond, president of the A.S.C.E., was reelected chairman of the finance committee.

PROPOSED MODIFICATIONS OF RELIEF ACT

As the result of careful study of a report of the Committee on Public Works of the A.S.C.E. regarding modifications in Title II of the Emergency Relief and Construction Act of 1932, by the Council's Committee on Government Expenditures, the Assembly recommended that, for the purpose of aiding the directors in making the Act more effective in the attainment of its objects, it seemed desirable to modify or remove some of the restrictions, leaving these matters more in the discretion of the directors, and otherwise to liberalize Section 201 of the Act by (*a*) Removing the self-liquidating stipulation; (*b*) Limiting the projects only to those which are needful and economically sound; (*c*) Providing that a municipality may set up such agency as may be satisfactory to the Reconstruction Finance Corporation (to regulate rents, etc., in housing projects); (*d*) Increasing the kinds of work devoted to the public use, which are eligible for loans; (*e*) Removing the restriction relative to taxation; and (*f*) Reducing the interest rates on loans made to the lowest point consistent with the condition that the Government shall be fully reimbursed for its loan.

DISCUSSION OF ECONOMIC REPORT

A special evening session was largely devoted to the past year's work of the Council's Committee on Economic Balance, and the contents of its second progress report were briefly described by Ralph E. Flanders, Chairman. After discussing the value of this report, which is the result of a great deal of intensified work and thought on the part of the members of the committee, the Assembly recommended that it be made available for publication and distribution.

GOVERNMENT REORGANIZATION

A recommendation that the Council authorize its officers to bring its views as to the necessity of reorganizing the technical functions of the Federal Government to the attention of the President-Elect and the new administration in furtherance of the Council's effort to accomplish a proper consolidation of Federal construction agencies was adopted.

LEGISLATIVE ACTIVITIES

Various committees reported to the Assembly as to the features of pending or proposed legislation of interest to engineers. Some of the more important bills, and the actions taken by the Assembly relative to them, are as follows:

That the Council oppose H. R. 11051 (to provide for the leasing and other utilization of the Muscle Shoals properties in the interest of national defense and of agriculture, and for other purposes). This action was based upon a careful report made by a subcommittee of the Public Affairs Committee indicating that the proposed legislation is neither feasible, economical, nor sound from an engineering standpoint.

That the Council oppose S. 5044 (to abolish the National Advisory Committee for Aeronautics) in view of the probable reorganization of the Federal departments and in view of its judgment that if a change is made, the proper place for the Langley Memorial Aeronautical Laboratory is in the Department of Commerce rather than the War Department.

That the Council strongly oppose S. 5267 and other bills, designed to limit the work hours of individuals engaged in the manufacture of goods on the ground that this subject is not a proper one for Federal legislation. In adopting this stand, the Assembly made it clear that its action was not to be interpreted as opposition of the engineering profession to shorter working hours.

That the Council support H. R. 8681 (to develop American air-transport services overseas, to encourage the construction in the United States by American capital of American airships for use in foreign commerce, and to make certain provisions of the maritime law applicable to foreign commerce by airship).

POLICIES ADOPTED—COMMITTEES AUTHORIZED

The Assembly considered and expressed its opinion on several important policies relating to public affairs of an engineering interest. The recommendation that the Council urge engineering groups in each state to actively participate with others in an endeavor to have the proposed Uniform Mechanics' Lien Act adopted by the several state legislatures, was approved.

The Assembly was advised of the excellent progress being made by the Federal Employment Stabilization Board. It adopted a recommendation that the Council cooperate in an effort to bring to the attention of state legislatures the advisability of setting up state and local employment stabilization boards to permit advanced planning of public works.

The Assembly expressed approval of the better-housing movement and authorized the officers of the Council to bring this movement to the attention of its state committees on engineers and employment for their consideration and participation as opportunity might present itself.

The Assembly authorized the appointment of a special committee to consider such problems relating to tax policies as might be called to the attention of the Council. It also authorized the appointment of a special subcommittee to study legislation designed to extend the Federal classification provisions to Government employees in the field service.

LEGISLATION REGARDING REGULATION OF TRANSPORT AGENCIES

The Assembly considered a report by a subcommittee relative to legislation for regulation of interstate commerce and adopted the following resolution:

WHEREAS, our national system of transportation comprises railroads, highways, pipe lines, waterways, and airways, and

WHEREAS, the only present Federal regulation of such transportation is that of the Interstate Commerce Commission over the railroads; therefore

Be It Resolved, that American Engineering Council favors the general principle of extending equitable government regulation to cover all forms of interstate transportation.

ADMINISTRATIVE BOARD

The officers of the Council for 1933 are: William S. Lee, President; John F. Coleman, R. C. Marshall, Jr., L. B. Stillwell, and W. H. Woodbury, Vice-Presidents; Farley Osgood, Treasurer; and L. W. Wallace, Executive Secretary. These with twenty-two representatives of societies and regional districts form the Administrative Board. The A.S.M.E. representatives are: L. P. Alford, Paul Doty, R. E. Flanders, Joseph W. Roe, and D. Robert Yarnall.

Dr. Elihu Thomson to Be Honored at a Dinner in March

ON MARCH 29, leaders in science, engineering, education, and industry will honor Dr. Elihu Thomson, Hon. Mem. A.S.M.E., the distinguished engineer and inventor, upon the occasion of his eightieth birthday, at a dinner to be held at the Massachusetts Institute of Technology, of which Dr. Thomson was acting president from 1920 to 1922, and of the corporation of which he is now a life member.

Preceding the dinner there will be an afternoon conference on the historical development of the applications of electricity, recent experimental trends, and latest theories of electricity and matter. It is also planned to have an impressive exhibit of many of Dr. Thomson's inventions and contributions in the electrical field.

Engineers' Day at the Chicago Exposition

WEDNESDAY, June 28, has been designated as "Engineers' Day" at the Century of Progress Exposition to be held in Chicago this summer. Plans call for an assembling of engineers at the Fair Grounds at 9:30 a.m., following which visits will be made to various scientific exhibits under suitable guides and in a way to exemplify them from the engineering viewpoint. After luncheon, at which addresses will be made by prominent scientists and engineers, the visiting of exhibits will be resumed. In the evening there will be a banquet at the Stevens Hotel, at which accommodations will be provided for 2500 guests.

The Chicago Power Show, formerly a February event, will be held during the week of June 25–30 at the Coliseum, and early indications are to the effect that the 85,000 sq ft of the building will be completely utilized by exhibitors.

"Engineers' Day" is a feature of Engineering Week, June 25 to 30, during which The American Society of Mechanical Engineers and numerous other engineering societies will hold meetings in Chicago.

Engineers' National Relief Fund

THE Engineers' National Relief Fund, a joint activity of the Four Founder Societies, has continued to aid members of these Societies during the present winter. Whereas its resources are not large, it still has available funds to take care of worthy cases, especially when they happen to be members who reside outside the larger communities and in places where other forms of relief work are not accessible to them. Members of the Societies who know of other members needing aid, or in fact of any worthy cases where engineers are in dire circumstances, are encouraged to report particulars to the Secretary of the Fund.

The relief offered is in the form of a loan, in return for which the recipient signs a note which does not bear interest nor require any endorsement or the deposit of any collateral.

Candidates for Membership in the A.S.M.E.

The application of each of the candidates listed below is to be voted on after March 25, 1933, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

NEW APPLICATIONS

ADOLPHUS, KENNETH B. H., Chicago, Ill.; BACKER, GERALD H., Summit, N. J.; BARKER, HERBERT, Queretaro, Qro., Mex.; BARTHOLET, DONNELL F., Seattle, Wash.; CHAMPION, C. H., London, England (Rt); CLARK, S. W., Tampico, Tamps., Mex.; DIXON, JOHN J., Newark, N. J.; EMORY, V. H., Madawaska, Me.; FARR, DONALD E., Waucoma, Iowa; GERMAN, WILBUR W., Butte, Mont.; HOLT, JAS., Cambridge, Mass.; HOPKINS, ARTHUR G., Maspeth, L. I., N. Y.; HYDEN, EUGENE B., JR., Chattanooga, Tenn.; KALB, JOS., Brooklyn, N. Y. (Rt); KASER, ARTHUR J., Burnt Ranch, Ore.; KOOY, FRANK C., San Francisco, Calif.; KOUSMIN, SERGE, Leningrad, U.S.S.R.; LUDWICKSON, JAS. K., Walthill, Neb.; MACKINTOSH, WM. D., Tulsa, Okla.; MALLORY, HENRY R., S. Manchester, Conn.; MARDEN, RICHARD G., Worcester, Mass.; MOKSU, WALTER H., Cambridge, Mass.; O'CONOR, FRANK, Chicago, Ill.; REGAN, JOS. D., San Francisco, Calif.; ROCKEFELLER, WM. C., Pasadena, Calif.; SMITH, JOHN R., Lewistown, Pa.; SPAHR, ROBERT H., Flint, Mich.; SWANSON, ALF E., Anaconda, Mont.; THOMAS, VINCENT P., Brookline, Pa.; TURNER, OTIS L., East Falls Church, Va.; WAALAND, THOS., Brooklyn, N. Y.; WATNEY, JAS. R., Oakland, Calif.; WEIS, GERALD F., Nyack, N. Y.; YOUNG, GERALD O., Dobbs Ferry, N. Y.; ZIEGLER, WILFRED L., North Bergen, N. J.

CHANGE OF GRADING

Transfers From Associate-Member:

ECKBERG, A. RALPH, Rochester, N. Y.; EMANUELSEN, JOHAN, Detroit, Mich.; HAHN, C. A., E. Pittsburgh, Pa.; POWELL, KNOX A., Minneapolis, Minn.; STEPANOFF, ALEXEY J., San Francisco, Calif.; SYSKA, A. G., New York, N. Y.

Transfers from Junior:

BURGER, GEO. E., Ruby, N. Y.; FREY, ALFRED T., Chicago, Ill.; GARDEN, NELSON B., New York, N. Y.; HORST, C. A., Waltham, Mass.; PARR, JOHN B., Lance Creek, Wyo.; ROGERS, JOS. E., Toronto, Ont., Can.; TSVETKOFF, A., San Francisco, Calif.; WILSON, JOHN A., JR., Tenafly, N. J.; WALKER, JOHN E., Puunene, Maui, Territory of Hawaii; WOLFE, BERNARD J., Yonkers, N. Y.

Coming Meetings of A.S.M.E. Local Sections

BALTIMORE: March 16. Speaker: Dean A. A. Potter, President of The American Society of Mechanical Engineers.

CHICAGO: March 30. Auditorium of the Engineering Building. Annual Machine Shop Practice Meeting with afternoon and evening sessions. Papers will show trend and interesting developments of machine tools, new cutting metals, and latest designs in boring bars, and multiple cutting tools.

PHILADELPHIA: March 28. The Philadelphia Engineers' Club. Subject: Purchasing and Distribution of Engineering Materials, to be presented by two speakers, one dealing with the problems of the purchasing agent, and the other with those of the sales engineer. At a simultaneous session it is expected that Burton W. Marsh, Director of Safety, Washington, D. C., will discuss the subject of City Traffic.

METROPOLITAN: March 15 Room 1101, Engineering Societies Bldg., 29 West 39th St., New York, at 8:00 P.M. Subject: Semi-Luminous Flame Obtained in Heavy Domestic Fuel Oil in a Specially Designed Furnace. Speaker: G. L. Mikeska.

March 7. Room 502, Engineering Societies Bldg., 29 West 39th St., New York, at 8:00 P.M. Subject: Gas Compressors.

March 16. Meeting to be held in Newark, N. J. Subject: Management of Planned Industries in Soviet Russia. Speaker: Walter Polakov.